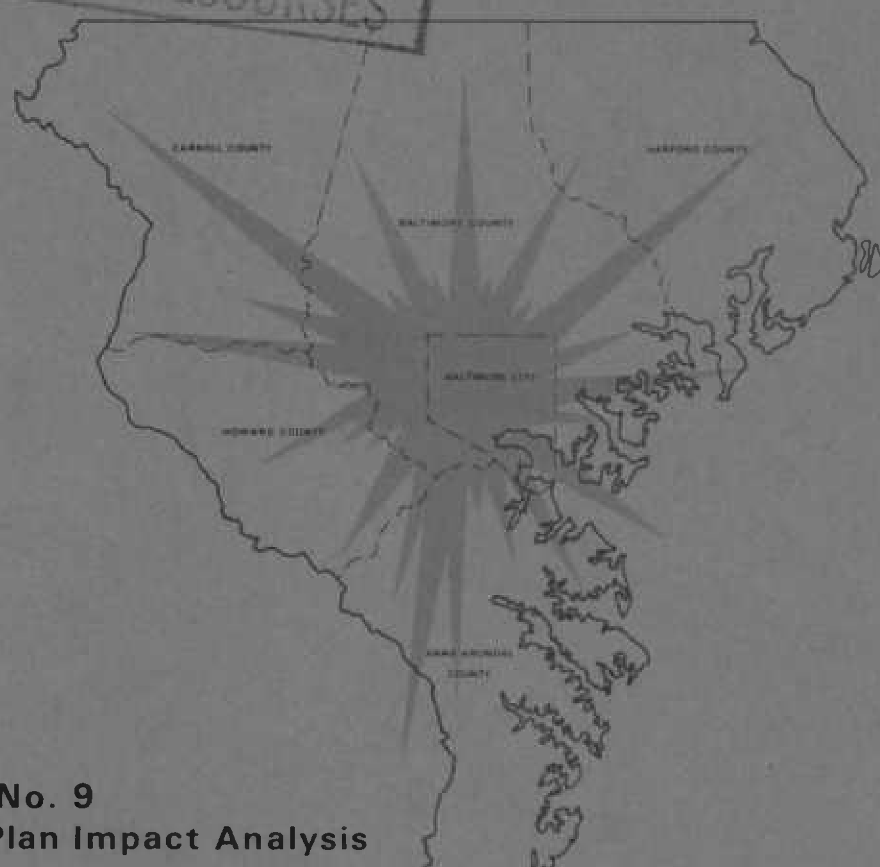
Baltimore Regional Environmental Impact Study



Technical Memorandum No. 9
Transportation Control Plan Impact Analysis

Alan M. Voorhees & Associates, Inc.

BALTIMORE REGIONAL ENVIRONMENTAL IMPACT STUDY

TECHNICAL MEMORANDUM NO. 9

TRANSPORTATION CONTROL PLAN IMPACT ANALYSIS

Prepared for the
INTERSTATE DIVISION FOR BALTIMORE CITY

by

PLANNING ENVIRONMENT INTERNATIONAL
a division of
ALAN M. VOORHEES & ASSOCIATES, INC.
7798 Old Springhouse Road
Westgate Research Park
McLean, Virginia 22101

1976

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SUMMARY

The purpose of this Technical Memorandum is to update the analysis of air pollution from the original Baltimore Regional Environmental Airport Study (BREIS) Technical Memorandum No. 3, "Air Quality Analysis." This document includes the effects of the Transportation Control Plan (TCP) and stationary source controls promulgated by the U.S. Environmental Protection Agency and the State of Maryland after September 1973. The results indicate the expected effects of the promulgated control measures on the regional air pollutant emissions as related to the 3–A Interstate highway system. There is no discussion of concentrations of pollutants, or air quality, as concurrent studies will address the broader issue of regional air quality analysis.

This report is not intended to be a commentary on the EPA promulgation, nor on other air quality in the region, but rather is intended to describe the relative magnitude and direction of the effects of the Transportation Control Plan and its relation to the 3–A System. This report is subject to review as the regulations and technologies are adjusted over time. It does, however, present the best available set of assumptions at the time of the study.

The Transportation Control Plan (TCP) was promulgated for the Baltimore Intrastate Air Quality Control Region (AQCR) by EPA on December 12, 1973 (38 FR 34240); the State of Maryland issued regulations for stationary source control on October 3, 1973. Both of these issuances were too late to be included in the original BREIS analysis.

The Transportation Control Plan is directed at meeting the reduction in emissions required to attain the photochemical oxidant and carbon monoxide air quality standards. The U.S. Environmental Protection Agency estimated that a 70 percent reduction in 6–9 a.m. hydrocarbon emissions is required to meet the oxidant standard. EPA also suggests that the measures required to meet the oxidant standard will also allow attainment of the CO standards.

The specific control measures in the TCP suggest that, in addition to emission reductions due to emission control devices, vehicle miles of travel (VMT) reduction measures and some form of gasoline rationing are necessary to meet the required emission reductions. These latter control measures may impact VMT growth projections. Therefore, this study also reviewed the revisions in VMT projections which may be required to reflect the TCP.

The results are therefore framed to answer the following questions:

- What is the effect of the Transportation Control Plan on projected emissions with and without the 3–A system?
- What is the effect of individual TCP control measures on the 3–A and resultant projected VMT and emissions?
- Is gasoline rationing required to maintain the standards with or without the 3–A?

GENERAL APPROACH

The general approach to the analysis was structured as follows:

- Develop emission estimates for each alternative for carbon monoxide (tons/year), hydrocarbons (tons/peak period), oxides of nitrogen (tons/year)
- Apply TCP control strategies to 1983 and 1995 alternatives and estimate resultant regional emissions
- Determine the percent reduction in emissions obtained
- Compare the hydrocarbon reduction obtained to the 70 percent reduction required to meet the oxidant standard

Impacts of the controls are assessed for several alternatives as shown in Table 1.

The Transportation Control Plan measures evaluated include, in addition to the Federal Motor Vehicle Control Program (FMVCP):

- Inspection and maintenance
- Retrofit strategies

Table 1. Alternatives

Alternative	Year	Assumptions
1[1]	1972	Existing
3[2]	1983	3-A complete, Phase 1 of Rapid Transit Plan complete, other GDP highways as existing and programmed
5[2]	1983	No 3-A beyond what is existing and under construction, other assumptions as in Alternative 3
6	1995	3-A complete, Rapid Transit complete as in the GDP, other highways as in the GDP
9	1995	No-build, no 3-A beyond that existing and under construction, other highways as existing or under construction, Rapid Transit as in the GDP

[1]Derived from BREIS Alternative 1 (1970)

[2]Derived from BREIS Alternatives 3 and 5 (1980)

- Traffic flow improvements
- VMT reduction measures: exclusive bus and carpool lanes, carpool locator, bikeway program, parking restrictions, parking management
- Gasoline distribution limitations

The additional stationary source controls promulgated by Maryland on October 3, 1973, include controls on:

- Industrial process heating
- Solvent usage
- Gasoline storage and handling

The analysis results assume the control measures are applied in the order defined in the TCP Technical Support Document prepared by EPA. This assumes gasoline rationing is applied last, up to the amount required to meet the 70 percent hydrocarbon reduction. In order to evaluate the contribution of each measure to the total reduction required, each measure is also evaluated independently.

The stationary source controls and FMVCP are applied first to obtain the projected emissions without the TCP. The TCP control measures are then applied in order, as suggested by the Federal Register and the Technical Support Document. The effectiveness of each measure has been determined using the following sources for all measures, except bus lanes and carpool programs:

- Compilation of Air Pollutant Emission Factors, AP–42–Supplement 5–U.S. EPA, unreleased draft, March 1975. (At the time of the study, this document was authorized for use; it has subsequently been revised, but the revisions do not appear to substantively alter the results.)
- Heavy-Duty Retrofit—A Status Report, Norman Friberg—City of New York, Department of Air Resources, September 1974 (and correspondence March 1975).
- Technical Support Document for the Transportation Control Plan for the Baltimore Interstate Region. U.S. EPA, draft report, March 1974.

This analysis was conducted at a time of relative uncertainty with respect to regional air pollution control plans such as the Transportation Control Plan and the Air Quality Maintenance Plan. Thus, it was necessary to make certain assumptions in order to estimate air pollutant emissions associated with the future alternatives under consideration. In addition, several changes in the baseline data, the construction schedule for the 3–A system, EPA emission factors, and projection assumptions occurred since the preparation of the original BREIS Air Quality Analysis. In the following paragraphs, the principal assumptions applied in this study are discussed in terms of the rationale for their selection and their significance to the analysis.

General Assumptions

- Base Year — 1972 was used as the base year in this analysis, rather than 1970 which was used in BREIS Technical Memorandum No. 3. This was because EPA used 1972 baseline air quality data in the determination of emission reduction requirements. This change enabled the analysis to incorporate more complete and updated data into the baseline emission inventory.

- 3-A System Construction Schedule — Because of the extended construction schedule for the 3–A system, the expected year of completion was assumed to be 1983 instead of 1980. Corresponding adjustments were made to the other inputs, mainly traffic, as discussed below.

- TCP Control Measures — The TCP control measures were assumed to be applied in order, as suggested in the promulgated plan and the EPA Technical Support Document. Gasoline rationing was assumed to be applied last, up to the amount required to meet the 70 percent hydrocarbon reduction by May 31, 1977.

- Effects of State Implementation Plan and Air Quality Maintenance Plan — The emissions projected for 1983 and 1995 in this analysis reflected only existing emission controls and regulations promulgated by the EPA and the Bureau of Air Quality Control (BAQC). They did not consider the potential emission limitations which may be required by the State Implementation Plan (SIP) and Air Quality Maintenance Plan. The SIP to be revised and the Baltimore Region Air Quality Maintenance Plan to be developed will limit the regional emissions to the levels that the air quality standards will be attained and maintained within the planning periods (40 CFR 51). Without considering these potential controls, the analysis tends to overestimate the future emission projections. The effects of this assumption on analysis results will be discussed below.

Assumptions for Stationary Source Emissions

- Estimate of 1983 Emissions Based on 1980 Projections — The 1980 emissions projected in the BREIS Technical Memorandum No. 3 were used as 1983 stationary source emissions in this analysis. The rationale for this is that the 1980 projections originally assumed completion of the 3–A system. With completion of the 3–A system delayed to 1983, it is reasonable to assume the related industrial and stationary source growth would generally reflect a corresponding adjustment.

Assumptions on Mobile Source Emissions

- Vehicle Classification — The vehicle classifications used in the TCP and BREIS Technical Memorandum No. 3 are different from those used in the revised EPA Compilation of Air Pollutant Emission Factors (AP–42). The primary difference is related to the gross vehicle weight of heavy-duty vehicles (6,000 lbs. vs. 8,500 lbs. in the later version). The following assumptions were made to adjust the vehicle mix by class to account for the revised classification for estimating mobile source emissions, based on national statistics:
  - The light-duty gasoline truck class includes 2/3 previously defined light-duty vehicles and 1/3 medium-duty vehicles.
  - The heavy-duty gasoline vehicle class was assumed to include 1/3 medium-duty and 2/3 heavy-duty vehicles, as previously defined.
- Addition of Catalytic Retrofit of Heavy-Duty Gasoline Vehicles — The catalytic retrofit of heavy-duty gasoline vehicles was added to the promulgated control programs for the purpose of this study. This addition was based on the result of a recent study on emission controls on heavy-duty vehicles in New York.(3) This control element was assumed to be applied to 1974 to 1977 models only, as the emissions of post-1977 models will meet the Federal emission standards.
- Estimate of 1972 and 1983 Travel Characteristics — Due to the adjusted baseline year and the anticipated year of completion for the 3–A system, several assumptions were made in order to extrapolate the 1972 and 1983 travel parameters from the previous BREIS work. The basic assumptions, which were developed in cooperation with the Baltimore Regional Planning Council, include:
  - VMT per vehicle over short time periods will be stable so long as there are no major changes in the highway system.
  - System average speed is stable over short time periods in the absence of major system changes.

- Regional average trip length is stable without major system changes.

Based on these assumptions, the 1972 and 1983 VMT can be extrapolated from the 1970 and 1980 data by considering the growth in vehicle population respectively.

- Traffic Characteristics — The 6-9 a.m. VMT was assumed to be equal to the two-hour p.m. peak period, which was 20 percent of 24-hour VMT based on the BREIS work.

- Based on the estimated average trip lengths and the EPA definition for different vehicle operational phases, the percentage of vehicles operating in cold start, hot start, and hot stablized conditions used in emission factor calculations were assumed as follows:
  - All work trips are in a cold start condition.
  - 50 percent of all non-work trips made in non-catalytic vehicles are in a cold start condition.
  - 75 percent of all non-work trips made in catalytic vehicles are in hot start condition.
  - 25 percent of all non-work trips made in catalytic vehicles are in cold start condition.

IMPACT OF THE TCP

The results of the analysis are framed to answer the questions noted above.

They are summarized in Tables 2 and 3 and Figures 1 and 2. Tables 2 and 3 list the independent reductions in carbon monoxide, and peak-period (6–9 a.m.) hydrocarbons for each control measure included in the Transportation Control Plan. The total reduction given in the tables is the composite impact of all measures applied according to the order and detailed procedures and assumptions described in the text.

Several conclusions which can be derived from these results are as follows:

- In all alternatives, the mobile source emission control measures included in the strategy (excluding gas rationing) account for less than 10 percent of the 70 percent hydrocarbon reduction guideline.

Table 2. Summary of Transportation Control Plan Emission Reductions for Peak Period (6 to 9 a.m.) Hydrocarbons

	1983				1995			
	Alternative 3		Alternative 5		Alternative 6		Alternative 9	
	T/P.P.	Percent of Base Yr.	T/P.P.	Percent of Base Yr.	T/P.P.	Percent of Base Yr.	T/P.P.	Percent of Base Yr.
1972 Total peak period emissions/base year	45.56	100.0	45.56	100.0	45.56	100.0	45.56	100.0
Reduction required to reach/maintain NAAQS	31.89	70.0	31.89	70.0	31.89	70.0	31.89	70.0
STATIONARY SOURCES								
1972 Stationary sources (pre-T.C.P.)	12.23	26.8	12.23	26.8	12.23	26.8	12.23	26.8
Stationary sources remaining (T.C.P. growth)	9.06	19.9	9.04	19.8	10.81	23.7	10.50	23.0
MOBILE SOURCES								
1972 mobile sources (pre-T.C.P)	33.33	73.1	33.33	73.1	33.33	73.1	33.33	73.1
Future year mobile sources (w/FMVCP growth, w/o T.C.P.)	13.87	30.4	13.69	30.0	8.79	19.3	8.71	19.1

Table 2 (continued)

	1983				1995			
	Alternative 3		Alternative 5		Alternative 6		Alternative 9	
	T/P.P.	Percent of Base Yr.	T/P.P.	Percent of Base Yr.	T/P.P.	Percent of Base Yr.	T/P.P.	Percent of Base Yr.
(a) Reduction, FMVCP minus VMT growth	19.46	42.7	19.64	43.1	24.54	53.8	24.62	54.0
Reduction strategies (b) - (i)[1]:								
(b) Inspection/maintenance (LDV, MDV)	.86	1.9	.85	1.9	.56	1.2	.65	1.4
(c) VSAD retrofit, pre-1968 LDV's	.00	0.0	.00	0.0	.00	0.0	.00	0.0
(d) (1) Air/fuel retrofit, 1971-1973 LDV's	.00	0.0	.00	0.0	.00	0.0	.00	0.0
(2) Air/fuel retrofit, 1971-1973 LDV's[2]	.09	0.2	.24	0.5	.00	0.0	.00	0.0
(e) (1) Catalytic retrofit, 1971-1975, LDV, MDV	.59	1.3	.75	1.6	.00	0.0	.00	0.0
(2) Catalytic retrofit, 1974-1977 HDV's[3]	.46	1.0	.46	1.0	.00	0.0	.00	0.0

Table 2 (continued)

	1983				1995			
	Alternative 3		Alternative 5		Alternative 8		Alternative 9	
	T/P.P	Percent of Base Yr.	T/P.P.	Percent of Base Yr.	T/P.P.	Percent of Base Yr.	T/P.P.	Percent of Base Yr.
(f) Air/fuel retrofit, prc-1974 MDV's	.03	0.1	.01	0.0	.00	0.0	.00	0.0
(g) Air/fuel retrofit, HDV's (pre-1974)	.06	0.1	.06	0.1	.00	0.0	.00	0.0
(h) Traffic flow improvements	.55	1.2	.53	1.2	.36	0.8	.32	0.7
(i) VMT measures	.24	0.5	.24	0.5	.16	0.4	.15	0.4
Total reductions due to strategies (b)-(i)	2.72	6.0	2.59	5.7	1.06	2.3	1.08	2.3
(j) Reduction. gasoline distribution limitation	8.54	14.2	8.47	12.0	4.87	10.7	4.48	9.8
Mobile sources remaining without gas distribution limitation	11.15	24.5	11.10	24.4	7.73	17.0	7.65	16.8
Mobile sources remaining with gas distribution	4.81	10.1	4.63	10.2	2.86	6.3	3.17	6.9

Table 2 (continued)

	1983				1995			
	Alternative 3		Alternative 5		Alternative 6		Alternative 9	
	T/P.P.	Percent of Base Yr.	T/P.P.	Percent of Base Yr.	T/P.P.	Percent of Base Yr.	T/P.P.	Percent of Base Yr.
Total reductions without gasoline distribution limitation	25.35	55.6	25.40	55.8	27.02	59.3	27.41	60.2
Total reductions with gasoline distribution limitation	31.89	70.0	31.89	70.0	31.89	70.0	31.89	70.0
Total emissions remaining without gas distribution	20.21	44.4	20.14	44.2	18.54	40.7	18.15	39.8
Total emissions remaining with gas distribution limitation	13.67	30.0	13.67	30.0	13.67	30.0	13.67	30.0
Total allowable emissions	13.67	30.0	13.67	30.0	13.67	30.0	13.67	30.0

[1] The line-by-line emissions reductions estimated are estimated for strategies (b)-(i) as if each were applied independently; however, the "total reductions due to strategies (b)-(i)" takes into account interrelationships between them--thus, the sum of the line-by-line reductions is not equal to "total reductions due to strategies (b)-(i)."

[2] This strategy was in the T.C.P. Technical Support Document for Baltimore but not in the Federal Register.

[3] Catalytic retrofit is applied to HDV's between 1974-1977 based on N.Y.C. data.

Table 3. Summary of Transportation Control Plan Emission Reductions for Annual Carbon Monoxide (Metric Tons x 10^3)

	1983				1995			
	Alternative 3		Alternative 5		Alternative 6		Alternative 9	
	T/P.P.	Percent of Base Yr.	T/P.P.	Percent of Base Yr.	T/P.P.	Percent of Base Yr.	T/P.P.	Percent of Base Yr.
1972 total peak period emissions/base year	554,974	100.0	554,974	100.0	554,974	100.0	554,974	100.0
Reduction required to reach/ maintain NAAQS	316,335	57.0	316,335	57.0	316,335	57.0	316,335	57.0
STATIONARY SOURCES								
1972 stationary sources (pre-T.C.P.)	85,049	15.3	85,049	15.3	85,049	15.3	85,049	15.3
Stationary sources remaining (T.C.P. growth)	69,109	12.5	69,047	12.5	82,647	12.5	82,081	12.5
MOBILE SOURCES								
1972 mobile sources (pre-T.C.P.)	469,925	84.7	469,925	84.7	469,925	84.7	469,926	84.7
Future year mobile sources (w/FMVCP, growth, w/o T.C.P.)	221,985	40.0	232,135	41.8	134,966	24.3	165,375	29.8

Table 3 (continued)

	1983				1995			
	Alternative 3		Alternative 5		Alternative 6		Alternative 9	
	T/P.P.	Percent of Base Yr.	T/P.P.	Percent of Base Yr.	T/P.P.	Percent of Base Yr.	T/P.P.	Percent of Base Yr.
(a) Reduction, FMVCP minus VMT growth	247,940	44.7	237,790	42.9	334,959	60.4	304,550	54.9
Reductions, strategies (b) - (i)[1]:								
(b) Inspection/maintenance (LDV, MDV)	17,451	3.1	18,232	3.3	13,593	2.4	12,819	2.3
(c) VSAD retrofit pre-1968 LDV's	0	0.0	0	0.0	0	0.0	0	0.0
(d) (1) Air/fuel retrofit, 1968-1971 LDV's	0	0.0	0	0.0	0	0.0	0	0.0
(2) Air/fuel retrofit, 1971-1973 LDV's[2]	1,591	0.3	1,668	0.3	0	0.0	0	0.0
(e) (1) Catalytic retrofit 1971-1975 LDV, MDV	12,432	2.2	13,023	2.4	0	0.0	0	0.0
(2) Catalytic retrofit 1974-1977 HDV's[3]	11,804	2.1	12,217	2.2	0	0.0	0	0.0

Table 3 (continued)

	1983				1995			
	Alternative 3		Alternative 5		Alternative 6		Alternative 9	
	T/P.P.	Percent of Base Yr.	T/P.P.	Percent of Base Yr.	T/P.P.	Percent of Base Yr.	T/P.P.	Percent of Base Yr.
(f) Air/fuel retrofit, pre-1974 MDV's	285	0.1	296	0.1	0	0.0	0	0.0
(g) Air/fuel retrofit, HDV's (pre-1974)	3,059	0.6	3,165	0.6	0	0.0	0	0.0
(h) Traffic flow improvements	1,978	0.4	2,146	0.4	1,617	0.3	1,570	0.3
(i) VMT measures	1,450	0.3	1,522	0.3	1,964	0.4	2,562	0.5
Total reductions due to strategies (b)-(i)	51,112	9.2	54,679	9.9	16,787	3.0	16,302	2.9
(j) Reduction, gasoline distribution limitation	100,302	18.1	103,457	18.6	74,453	13.4	87,357	15.7
Mobile sources remaining w/o gasoline distribution limitation	170,873	30.8	177,456	32.0	118,179	21.3	149,073	26.9
Mobile sources remaining with gasoline distribution limitation	70,571	12.7	73,999	13.3	43,726	7.9	61,716	11.1
Total reductions w/o gasoline distribution limitation	314,992	56.8	308,471	55.6	354,148	63.8	325,096	58.6
Total reductions w/gasoline distribution limitation	415,294	74.8	411,928	74.2	428,601	77.2	411,177	74.1

Table 3 (continued)

	1983				1995			
	Alternative 3		Alternative 5		Alternative 6		Alternative 9	
	T/P.P.	Percent of Base Yr.	T/P.P.	Percent of Base Yr.	T/P.P.	Percent of Base Yr.	T/P.P.	Percent of Base Yr.
Total emissions remaining without gasoline distribution limitation	239,982	43.2	246,503	44.4	200,826	36.2	225,878	40.7
Total emissions remaining with gasoline distribution limitation	139,680	25.2	143,046	25.8	126,373	22.8	143,797	25.9
Total allowable emissions	238,639	43.0	238,639	43.0	238,639	43.0	238,639	43.0

[1] The line-by-line emissions reductions estimated are estimated for strategies (b)-(i) as if each were applied independently; however, the "total reductions due to strategies (b)-(i)" takes into account interrelationships between them--thus, the sum of the line-by-line reductions is not equal to "total reductions due to strategies (b)-(i)."

[2] This strategy was in the T.C.P. Technical Support Document for Baltimore but not in the Federal Register.

[3] Catalytic retrofit is applied to HDV's between 1974-1977 based on N.Y.C. data.

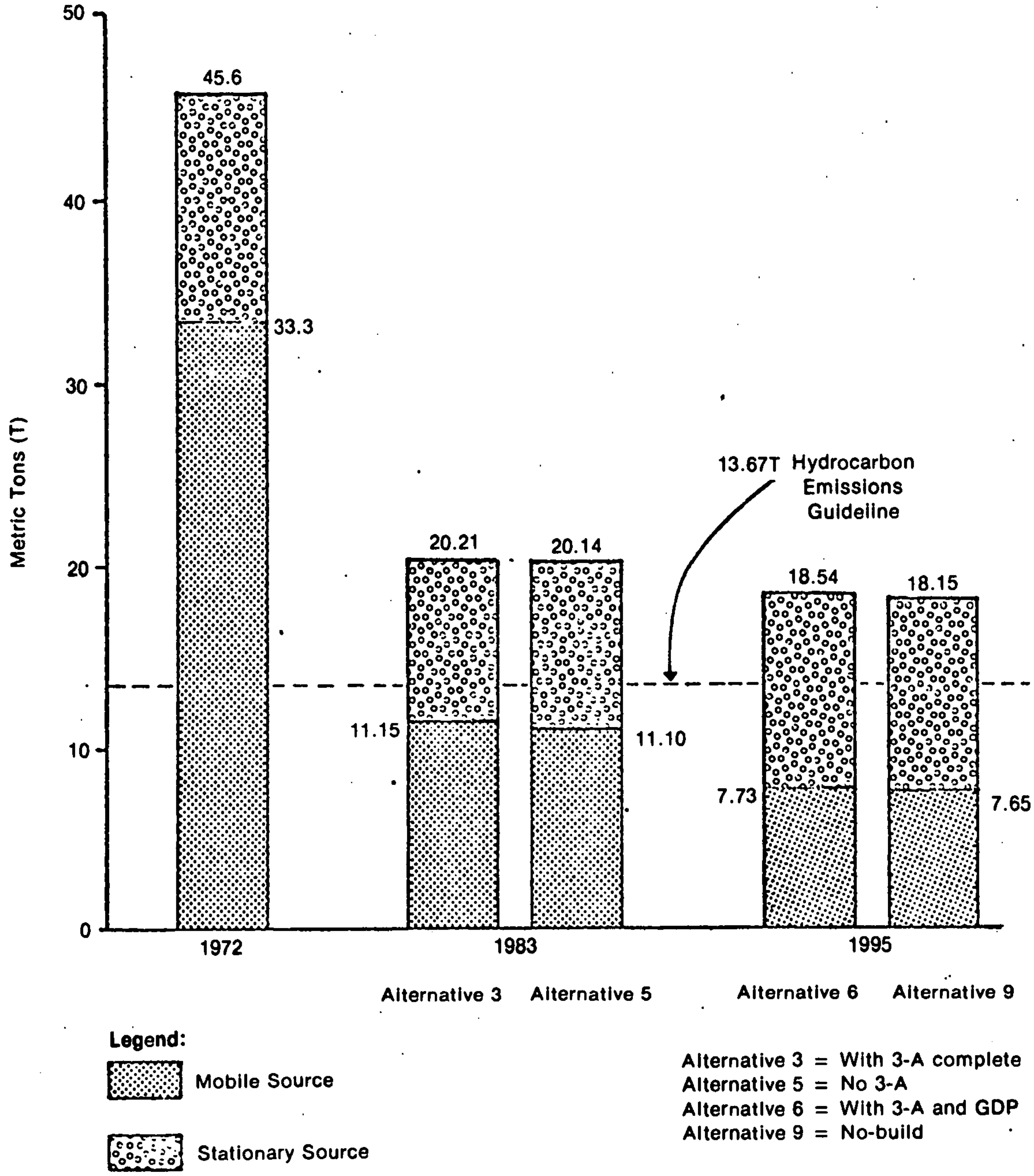

Figure 1. Impact of the Transportation Control Plan on Peak Period (6-9 a.m.) Hydrocarbons TCP (Minus Gas Rationing)

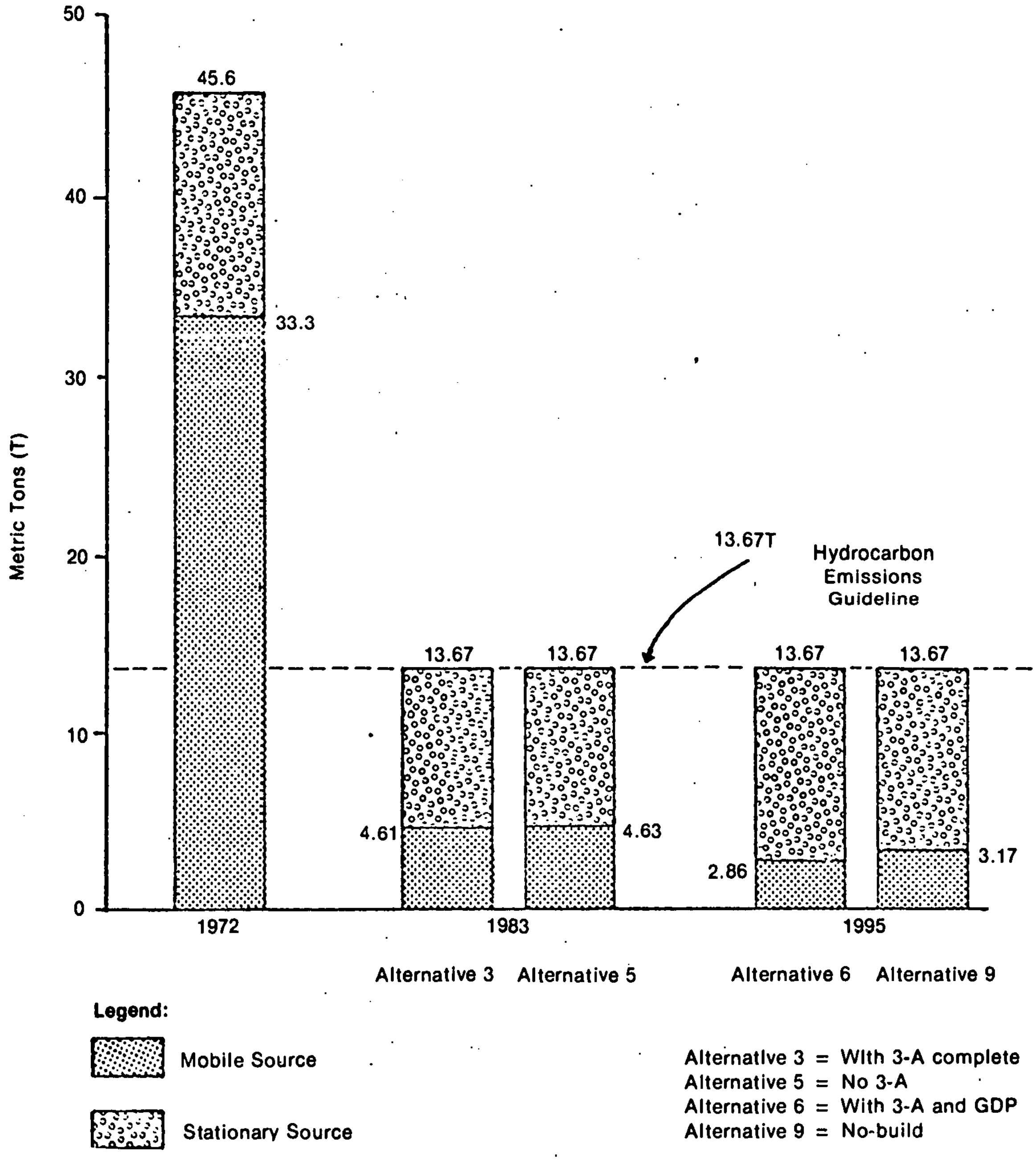

Figure 2. Impact of the Transportation Control Plan on Peak Period (6-9 a.m.) Hydrocarbons TCP (Including Gas Rationing)

- In 1983, the carbon monoxide emissions reduction will be within 1 percent of that reduction sufficient to meet the CO standards with or without the 3–A system with no gasoline rationing required. In 1995, the standards will be attained in both alternatives.

- In all alternatives, the resultant controlled emissions exceed the hydrocarbon guideline (without gasoline rationing).

- In 1983, Alternative 3 (complete 3–A) HC emissions exceed Alternative 5 (no 3–A) HC emissions by less than 1 percent.

- In 1995, Alternative 6 (3–A and General Development Plan) HC emissions exceed Alternative 9 (No-Build) by 2 percent.

- Stationary source emissions become about one-half of the remaining emissions in 1983 and exceed mobile source emissions by 1995.

Figures I and II illustrate the impact of the Transportation Control Plan (TCP) on peak-period (6–9 a.m.) hydrocarbon emissions. Figure I shows the controlled emissions for each alternative for the "TCP minus gas rationing." Figure II shows the controlled emissions for each alternative when gas rationing is applied as a last resort measure.

If gasoline distribution limitations —"gas rationing"—is applied to attain the oxidant standards:

- In 1983, about 58 percent gas rationing (VMT reduction) is required in both alternatives.

- In 1995, about 63 percent gas rationing is required in Alternative 6 (3–A and General Development Plan) and 59 percent in Alternative 9 (No-Build).

- The TCP will minimally reduce VMT and result in some additional flow improvement.

Initial conclusions relating to resultant emissions with and without the 3–A system in 1983 are as follows:

- The TCP (not including the FMVCP, stationary source controls and gas rationing) provides less than 10 percent of the 70 percent hydrocarbon reduction required to meet the oxidant standard.

- The resultant hydrocarbon emissions both with and without the 3–A (no gas rationing) exceed the allowable emissions.

- The resultant 1983 hydrocarbon emissions with the 3–A (Alternative 3) are higher than emissions in the no-build case (Alternative 5) by approximately 0.4 percent.

- Carbon monoxide emissions reductions are within 1 percent of requirements for both alternatives in 1983 without gas rationing and well within standards by 1995.

Initial conclusions relating to resultant emissions in 1995 with the GDP and the 3–A system (Alternative 6) and the no-build case (Alternative 9) are as follows:

- The TCP (not including the FMVCP, Stationary Source Controls and gas rationing) provides less than 10 percent of the 70 percent reduction required to achieve the standards in both cases.

- The resultant hydrocarbon emissions (no gas rationing) are greater than the allowable emissions but less than 1983 emissions in both alternatives.

- The resultant emissions are higher for Alternative 6 (complete 3–A) than Alternative 9 (no-build) by approximately 2 percent.

- Stationary source emissions represent the majority of emissions in 1995 in both alternatives and are greater than 75 percent of the allowable emissions.

If gasoline rationing is applied to meet the hydrocarbon reduction guidelines:

- In 1983, about 58 percent gas rationing (VMT reduction) is required in both alternatives.

- In 1995, Alternative 6 (3–A and GDP) require 63 percent and Alternative 9 (no-build) requires 59 percent gas rationing.

Potential Effects of Economic or Energy Programs on Study Results

Some consideration of changes in economic growth has been given in the analysis by revising the 1983 VMT projections. However, this does not consider any major changes due to gasoline shortages, oil embargoes, major recession, etc., which may occur within the projection timeframe.

The primary assumption inherent in the analysis is that the TCP will not induce major land use changes beyond that accounted for in BREIS land use projections. The kinds of major economic or energy reduction programs mentioned above would have a major impact on land use and resultant emissions. However, any consideration of such programs is beyond the scope of this study.

Potential for Implementation and Effectiveness of TCP Measures

The methodology described in this memorandum defines assumptions on the effectiveness of each control measure. These effectiveness rates are dependent upon several factors, including:

- Mobile source (LDV, HDV, etc.) and stationary source mix
- Time period for implementation
- Implementation and operation of the control measure
- Social acceptability of the measure
- Enforcement

In addition, the resultant impact on air quality of the measures is dependent upon:

- Meteorological conditions
- Background air quality
- Growth rate of controlled and uncontrolled sources
- Assumed effectiveness and implementation of FMVCP
- Assumed vehicle turnover rate

The potential range in each of these factors should be considered independently and simultaneously in order to fully comprehend the potential impact of the TCP on the 3–A and resultant emissions and air quality. However, such a sensitivity analysis is beyond the scope of this current study and may result in a composite range of effectiveness or impact so large as to be useless for planning purposes.

For example, gas rationing has been considered as an independent variable in the analysis for two reasons:

- It is socially unacceptable and therefore has a low potential for implementation.
- Its assumed effectiveness is so large as to hide the smaller variations in results which are responsive to the analysis questions.

Effects of Assumptions on Results

In general, the assumptions applied are the best currently available, and they tend to be conservative in order to estimate the "worst case" future impacts. Thus, the results of this analysis are evaluated in relative terms, using comparison among alternatives rather than absolute values as the basis for evaluation.

Among the various assumptions applied, the most critical one is that related to the effects of regional future air pollution control plans.

This analysis considered mobile source emission controls, but none of the potential stationary source controls to be developed. Thus, the emission projections indicate that the stationary source emissions represent a major portion of the total emissions in 1983 and 1995.

The reason for not considering the future stationary source controls was that the analysis was intended to evaluate the "worst case" impacts. However, it should be noted that the state will have to revise the State Implementation Plan to meet air quality standards by 1977 and develop an Air Quality Maintenance Plan for the Baltimore region to attain and maintain air quality standards within the next 10 years (40 CFR 51). In addition to the promulgated Transportation Control Plan, the revised or developed plans will specify the necessary emission limitations on existing and future stationary sources. If these plans are implemented, the future stationary source emissions will be less than those estimated in this study. The 1983 and 1995 emissions may meet the 1977 hydrocarbon reduction guideline, and gasoline rationing may not be necessary.

Another assumption which may have important effects on the analysis results is that related to the effects of the promulgated Transportation Control Plans on regional vehicle miles of travel (VMT). The future VMT projections used in the analysis did not consider the potential effects of the control strategies. If the promulgated TCP is implemented prior to the 1983 or 1995 projection years, the VMT projections will be less than those originally estimated. Therefore, the mobile source emission projections can be considered as somewhat "overestimated." The quantitative effects of the TCP on regional VMT growth would require a detailed investigation.

The other assumptions, including travel parameters, vehicle mix, construction schedules, and others, may have less important effects on the analysis results. A change in these assumptions will result in a marginal to negligible change in the emission projections. However, the analysis results and conclusions are unlikely to be reversed by a reasonable change in these assumptions.

LIMITATIONS OF ANALYSIS

With the exception of those areas where new data or assumptions were used, the analysis procedures follow closely that given in the EPA Technical Support Document. The limitations of the analysis include those factors which are affected by use of a regional approach:

- Regional average speeds do not adequately reflect speed correction and resultant emissions. Traffic flow improvements are underestimated, and HDV emissions are overestimated by such procedures.
- The control measure effectiveness should be considered at the level to which it applies.

Parking restrictions, bus lanes, and other measures may have a significant local impact. However, the regional level effectiveness is insignificant. In addition, one purpose of the analysis is directed at defining the fractional increase in emissions due to the 3–A system. There are two problems with interpreting the results as presented:

- The regional approach obscures the emissions reductions due to improved flow on the 3–A system.
- Since Alternative 6 includes the full GDP highway plan, the incremental effects of the 3–A system are not isolated; it must be noted, ing road system furnished by the other major highways in the region.

The results indicated that the primary impact in the long term will arise from the land uses associated with development. This should receive further analysis in the air quality maintenance plan to be developed for Baltimore.

1.0 INTRODUCTION

1.1 BACKGROUND

The Baltimore Regional Environmental Impact Study (BREIS) was initiated in the spring of 1973 to determine the potential environmental implications of constructing the 3–A system in Baltimore City. The BREIS was the culmination of a series of events related to transportation systems planning and highway construction in the Baltimore Region. Air pollution was one of six areas of environmental concern originally included in the study.

At the time the BREIS was initiated, many states, including Maryland, were in the process of revising their State Air Quality Implementation Plans to incorporate transportation controls and other new stationary source controls required to meet the air quality standards. The type of controls and the resultant impact of these controls on the 3–A system and resultant regional emissions could not be anticipated at that time. Such stationary source control measures and the Transportation Control Plan (TCP) for the Baltimore Region were subsequently promulgated on October 3 and December 12, 1973.

The following sections provide brief descriptions of the BREIS and the TCP which are presented as background and a ready source of definition of terms used in the current technical memorandum.

<u>The Baltimore Regional Environmental Impact Study</u>

The highway system which is the subject of this study was defined in a previous comprehensive study of the Interstate plan in Baltimore by Urban Design Concepts Associates,(1) as well as in several other planning studies that preceded it.(2) This system, shown in Figure 1–1, is known as the 3–A system. It was adopted in 1969 by the Baltimore Planning Commission and subsequently approved by the Regional Planning Council (RPC) for inclusion in the General Development Plan. The 3–A system consists of several segments of I–70N, I–83, I–95, the I–395 and I–170 spurs, and City Boulevard, an arterial link not on the Federal Interstate System.

With the passage of the National Environmental Policy Act of 1969 (NEPA), many of the environmental concerns which had been expressed by various groups in the Baltimore region received official recognition. Section 102(2)(C) of this act requires a detailed statement for any proposed Federal action affecting the environment, including:

- The environmental impact of the proposed action
- Any adverse environmental effects which cannot be avoided should the proposal be implemented
- The relationships between the local short-term uses of man's environment and the maintenance of long-term productivity

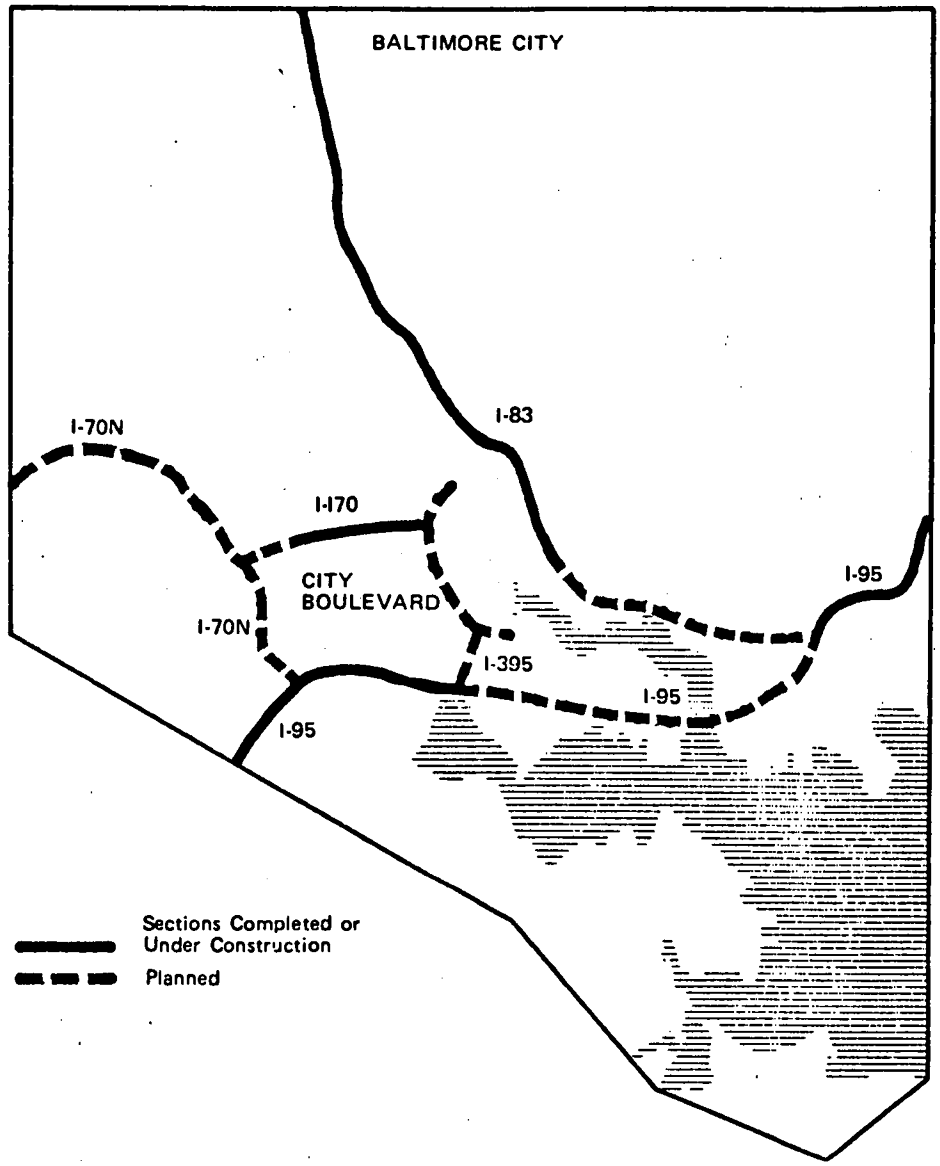

Figure 1-1. Baltimore 3-A System

- Any irreversible and irretrievable commitments of resources that would be involved in the proposed action should it be implemented

For Federal highway construction, these requirements were reinforced by provisions of the Federal-Aid Highway Act of 1970 (Section 136), the Department of Transportation Act as amended (Section 4(f)), the Clean Air Act Amendments of 1970, and the Historic Preservation Act of 1966. The Federal Highway Administration (FHWA), in its Policy and Procedures Memorandum 90–1, has directed that these provisions be fulfilled by highway agencies for each highway construction project.

In response to these requirements, the Maryland Department of Transportation (MdDOT) has submitted a draft environmental impact statement (EIS) for each segment of the 3–A system as it reached the location and design approval stage.

However, a citizen suit was filed in 1972 against the U.S. Department of Transportation (Movement Against Destruction (MAD) vs. Volpe) charging that the 3–A system as a whole represented a significant Federal action and that a regional environmental impact statement should be filed in addition to separate statements for each facility. Another question, relating to the Franklin-Mulberry Corridor (I–170) asserted that the EIS process had not been sufficient to meet NEPA and other Federal requirements. Rights-of-way had been purchased in this corridor, and the City would be required to return over $5 million to FHWA if construction on this segment did not begin by June 30, 1973.

Two other cases (Sierra Club, Inc. vs. Volpe and Lukowski vs. Volpe), also questioning the adequacy of the EIS process, were then pending in the courts. It was agreed that the relevant portions of all these cases would be heard concurrently on April 16, 1973.

As a result of this hearing, the court found on June 22, 1973, that "the applicable law does not require that an environmental impact statement be prepared for the 3–A system as such." Further, "components of the 3–A system are not necessarily so interdependent as to require the construction of all the 3–A system or none of it." The court continued that:

> It may be wise for the city, state, and Federal authorities to prepare in the near future a statement which considers those environmental impacts that should be determined with respect to the entire configuration, or major portions thereof. Such a statement would be included in one or more of the EIS's which will have to be prepared in the future for other sections of the highways in the 3–A system and which will, of course, also include and consider those environmental impacts that should properly be determined section by section or road by road.(3)

As a result of this decision, construction began in the disputed section of the Franklin-Mulberry Corridor on June 22, 1973.

Concurrent with the legal contest, the U.S. Environmental Protection Agency (EPA) was stressing the need for a regional environmental analysis for the 3–A system. In September 1972, based on a series of discussions, a consensus agreement between EPA and FHWA was reached. This agreement provided in part:

- For all remaining segments of the 3–A system under environmental review, neither PS&E (plans, specifications, and estimates) approval nor further right-of-way approval would be granted by FHWA until a regional impact consideration statement was prepared and circulated to FHWA, EPA, the U.S. Department of Transportation, and the Maryland Department of Health and Mental Hygiene, Bureau of Air Quality Control (BAQC).

- That the regional impact consideration statement will address those regional issues, identified by EPA in its various reviews, that cannot be addressed on a project basis and will include as a minimum:

  1. Cumulative (regional) air pollution impact of the various stages of completion of the currently envisioned 3–A system (including the MTA system) in the years 1978, 1980, 1985, and 1990.

  2. A detailed discussion of possible modification to the proposed system to mitigate air pollution problems. The effect of these changes on land use and local traffic patterns should be discussed. These modifications should include the options of:

     - Increased highway access to the MTA system
     - Impact of elimination of various segments of the 3–A system
     - Optimization of construction scheduling to minimize saturation of local street systems
     - Impact of the no-build alternative

It is in response to these actions and the desire of regional and local agencies to understand the socioeconomic, traffic, and environmental implications of the 3–A plan that the study presented in this series of reports is directed.

The conduct of the study, under the direction of the Interstate Division for Baltimore City (IDBC), was a joint effort by the consultant team and other regional and local agencies. Some of the work for this study was accomplished by RPC and MDOT, with assistance from AMV, as part of the "3–C" (cooperative, comprehensive, and continuing) planning process element of the Unified Transportation Planning Program in the Baltimore region.

The study process outlined in Figure 1–2 was directed toward the measurement of several regional environmental features through which the examination of the estimated future impacts that the 3–A system would have on:

- Socioeconomic and land use factors
- Traffic and travel demand
- Air quality
- Noise pollution
- Water resources and solid waste
- Ecologically sensitive areas

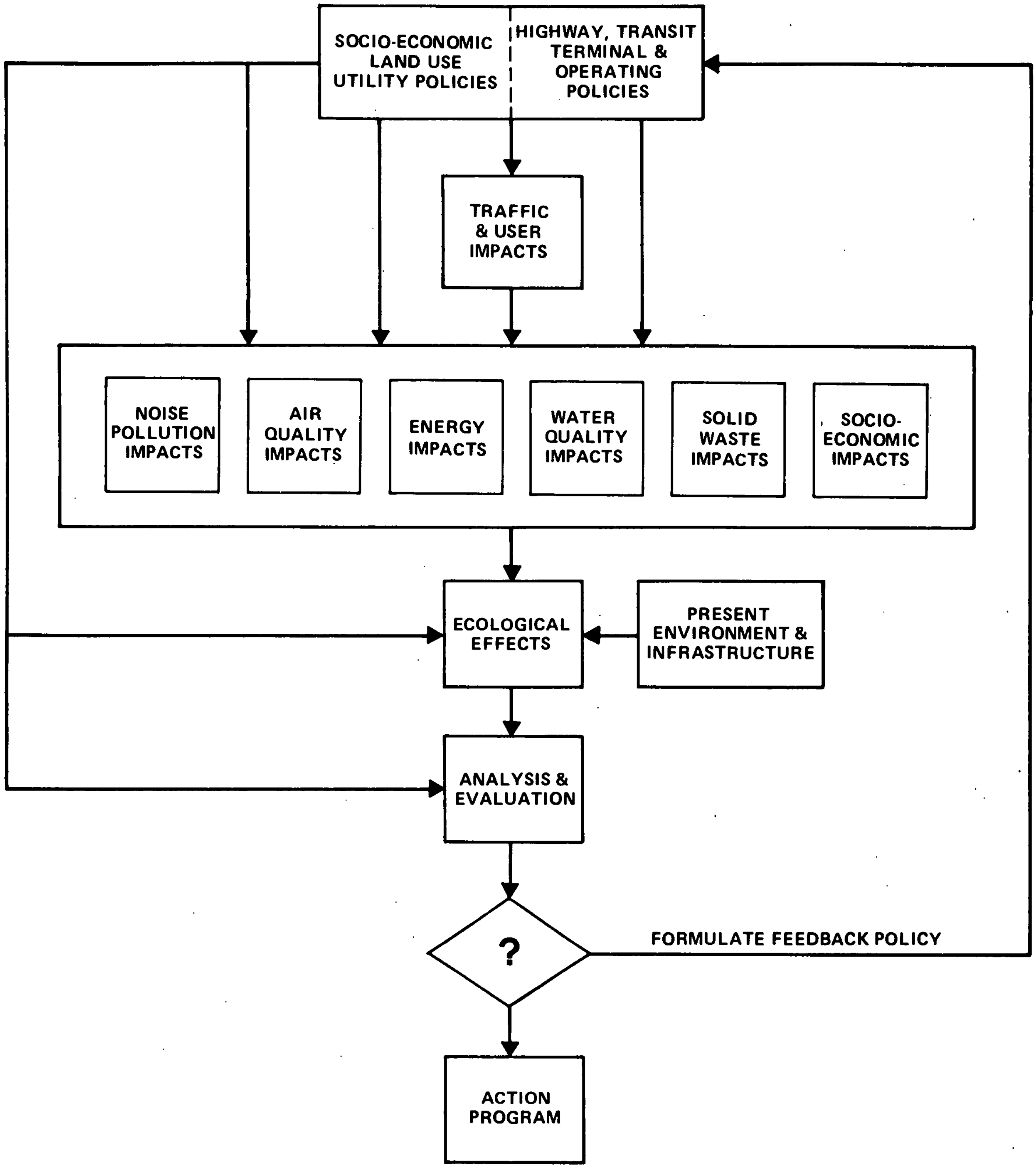

Figure 1-2. BREIS-Process for Evaluation of Alternatives

Subsequently, two other analysis areas which could significantly affect the 3–A system were selected for study—the analysis of energy consumption and the analysis of the effects of the Transportation Control Plan promulgated by EPA on December 12, 1973.

The study results are framed to answer the following broad questions:

- What were the regional environmental problems in 1970?
- Will there be regional environmental problems in the short-term (1980) with the 3–A system? Without the 3–A system?
- Will there be regional environmental problems in the long-term (1995) with the 3–A system? Without the 3–A system? With the GDP highway plan?
- What are the regional differences between alternatives?
- What regional effects can be attributed to the 3–A system?
- Is there a need for further study?

The study results are presented in nine technical memoranda as listed in the preface.

Description of Alternatives

To provide a basis for determining the extent to which future environmental conditions were related to the 3–A system as opposed to other factors, such as growth in population, the environmental consequences of several alternative transportation systems, including a "no-build" option, were also studied. These alternatives were devised jointly by the various agencies associated with the study, both as alternatives to the 3–A system and as a basis for determining the regional environmental consequences of major components of that system. These alternatives were selected to isolate various conditions and assess their impact on the region. One of the significant features of this procedure is that land use and socioeconomic activity policies were varied separately for each transportation alternative studied. This permitted an assessment of the predicted effects of changes in urbanization due to transportation policy on the region and demonstrates the interrelationships between transportation and land use.

The study area includes the jurisdictions represented in the RPC—Baltimore City, and Baltimore. Anne Arundel, Carroll, Harford, and Howard Counties, as shown in Figure 1-3. A comprehensive General Development Plan (GDP), which includes a land use pattern element, was adopted for the region in December 1972. It includes the full 3–A system, numerous freeways and other highways outside the City of Baltimore, and a regional rapid transit system comprised of six major lines. This plan serves as one alternative and is the basis for the examination of alternative transportation and land use assumptions for future years.

The transportation and land use alternatives studied in the first eight technical memoranda consist of three systems for 1980 and four systems for 1995. Only

Figure 1-3. Study Area—Baltimore Regional Environmental Impact Study

Alternatives 3 and 5 in 1980, and 6 and 9 in 1995 were examined for this technical memorandum. These alternative systems are shown in Table 1-1 and are briefly described below.

Originally, the study plan included a 1978 system for analysis, based on the premise that all of the 3–A system, except for the Fort McHenry bypass, could be completed by 1978; however, since the Phase I rapid transit lines would not be completed at least until 1980 and since revisions to contemplated construction schedules by IDBC have made the 1978 data meaningless, this was eliminated in favor of analyzing the no-build system in 1995. RPC and MDOT will continue the analysis for 1978, if necessary.

Phase I rapid transit will consist of 28 miles of rail running northwest to Owings Mills and south to Glen Burnie. All 1980 alternatives include the Phase I rapid transit; all 1995 alternatives are based on the GDP and include the full 6-legged rapid transit system, as well as an augmented bus system.

The differences among the 1980 alternatives are related to the 3–A system—in Alternative 3 the full 3–A system is assumed to be completed; in Alternative 4, the 3–A system will be completed, except for the Fort McHenry Crossing; and only existing Interstate facilties or those under construction were assumed in Alternative 5. Other programmed highway improvements which were assumed to be operational by 1980 include the Northwest Freeway and the Outer Harbor Crossing which is part of the Baltimore Beltway (I–695). The John F. Kennedy Expressway (I–95) northeast of Baltimore has been widened since 1970.

In 1995, the differences concern not only the 3–A, but also other planned GDP highway improvements. Examples include, in addition to those completed in 1980, construction of the Perring Freeway northeast of the City; upgrading and extension of U.S. 29 and the southern portion of Maryland Route 3; and widening of other facilities including U.S. 40, the Baltimore-Washington Parkway, U.S. Route 1, the Arundel Freeway, and Hilton Street in Baltimore City.

Alternative 6 includes the completed 3–A system and other GDP highway improvements while Alternative 7 includes GDP improvements with the exception of the 3–A system. Alternative 8 includes the 3–A, but no other GDP highway improvements except those under construction. Alternative 9 does not include either the 3–A or other GDP highway improvements, except those under construction.

The Transportation Control Plan

The Transportation Control Plan (TCP), promulgated by EPA for the Baltimore Intrastate Air Quality Control Region,(4) is based on the strategies proposed by the State of Maryland, which were augmented by sufficient additional control measures to permit the attainment of primary air quality standards for photochemical oxidants and carbon monoxide by May 31, 1977. In addition to the Federal Motor Vehicle Control Program (FMVCP), the control measures included in the Transportation Control Plan were as follows:

Table 1-1. Transportation Alternatives for Baltimore Regional Environmental Impact Study

ALTERNATIVE	YEAR	HIGHWAY ASSUMPTION		RAPID TRANSIT ASSUMPTION
		3-A INTERSTATE	OTHER HIGHWAYS	
1	1970	Existing	Existing	None
*2	1978	Existing and Programmed	Existing and Programmed	Phase I
3	1980	Complete	Existing and Programmed	Phase I
4	1980	Partial	Existing and Programmed	Phase I
5	1980	Existing and under construction	Existing and Programmed	Phase I
6	1995	Complete	GDP	GDP
7	1995	Existing and under construction	GDP	GDP
8	1995	Complete	Existing and under construction	GDP
9	1995	Existing and under construction	Existing and under construction	GDP

*Eliminated in favor of Alternative 9.

- Inspection and maintenance
- Retrofit strategies
  - Vacuum spark advance disconnect (VSAD) retrofit devices on all pre-1968 model year light-duty vehicles
  - Air/fuel retrofit of 1968-1971 light-duty vehicles
  - Catalytic retrofit of 1971-1975 light-duty vehicles
  - Air/fuel retrofit of pre-1974 medium-duty vehicles
  - Catalytic retrofit of 1971-1975 medium-duty vehicles
  - Air/fuel retrofit of all heavy-duty vehicles
- Traffic flow improvements
- Vehicle miles of travel (VMT) reduction measures, including exclusive bus lanes, carpool locator, bikeway program, parking restrictions, parking management
- Gasoline distribution limitations

The additional stationary source controls promulgated by Maryland on October 3, 1973, include controls on:

- Industrial process heating
- Solvent usage
- Gasoline shortage and handling

The TCP, as promulgated, was intended to provide the reduction in emissions and resultant air quality required to meet the carbon monoxide and photochemical oxidant standards. The estimation of the necessary reduction is based on the maximum air quality readings submitted by the State of Maryland in its Transportation Control Plan of June 15, 1973, as follows:

- <u>Carbon Monoxide</u> — Maximum 8-hour average CO reading of 21 ppm which occurred on August 5 and 6, 1971
- <u>Photochemical Oxidants</u> — Maximum 1-hour reading of 0.21 ppm which occurred on August 21, 1972

Based on EPA calculations using 40 CFR51, Appendix J, the Administrator of EPA determined that the peak period (6-9 a.m.) hydrocarbon emissions must be reduced by 70 percent of the 1972 emissions in the Baltimore area.(1) Since significantly greater emission reductions are required for hydrocarbons, the Administrator suggested that the controls necessary to achieve this 70 percent reduction will be sufficient to meet the carbon monoxide (CO) standards also.(1)

In calculating these emission reductions necessary to meet the standards, the EPA did not assume any growth due to the planned 3-A highway system, which would not be completed until beyond the May 31, 1977, deadline for attainment of standards. However, the Administrator stated that "any increase of emissions resulting from such a growth would be inconsistent with the need to reduce VMT to attain and maintain air quality standards."

The following analysis describes the predicted effects of the Transportation Control Plan on the region, given the assumptions available at the time of the study. For purposes of analysis, the target year for Alternatives 3 and 5 were adjusted to 1983 due to the anticipated slowdown of construction schedules for both highway and transit.

The State of Maryland and several major companies in the Baltimore area filed suit against EPA charging that EPA had not acted properly in promulgating some portions of the TCP. The Fourth Circuit U.S. Court of Appeals on September 19, 1975, set aside "as contrary to law" the provision of the plan which required establishment of an inspection and maintenance program, a retrofit program, and a bikeways program. In addition, the Employers Mass Transit Incentive Program was remanded to EPA for clarification. It should also be noted that draft legislation to revise the Clean Air Act includes several provisions which would considerably modify the assumptions and findings contained in this Technical Memorandum.

This report is not intended to be a commentary on the EPA promulgation, nor on other air quality/transportation planning in the region, but rather is intended to describe the relative magnitude and direction of the effects of the TCP and its relationship to the 3–A system.

Thus, this report is subject to revision as the regulations and technologies are adjusted over time. It does, however, present the best available set of assumptions at the time of preparation. These assumptions are specified in Section 2 of this report.

1.2 PURPOSE

The purpose of the analyses described in this Technical Memorandum is to update the results of the original air quality impact analysis in the BREIS Technical Memorandum No. 3, "Air Quality Analysis," so as to include the effects of the Transportation Control Plan (TCP) and stationary source controls promulgated by EPA and Maryland after September 1973. The results indicate the expected effects of the promulgated control measures on the 3–A system and the difference in total regional emissions with and without the 3–A system, including the General Development Plan. There is no discussion of concentrations of pollutants, or air quality, as this will be completed by concurrent studies being conducted in the region.

Significant changes in baseline data, projection assumptions, and emission factors have occurred since the preparation of the original BREIS air quality analysis. Therefore, the results of Technical Memorandum No. 9 are not directly comparable to the analysis results of Technical Memorandum No. 3. For example, the analysis baseline has been changed from 1970 to 1972 to reflect the air quality data base used in the TCP promulgation. Therefore, the calculated emissions reductions due to the TCP as shown in Technical Memorandum No. 9 cannot be subtracted from the original uncontrolled (no TCP) emissions in BREIS Technical Memorandum No. 3 to obtain the controlled (with TCP) emissions.

The specific control measures given in the TCP suggest that, in addition to emission reductions due to emission control devices, VMT reduction measures and some form of gas rationing are required to meet the required emission reductions. These latter control measures may impact VMT growth projections. Therefore, in addition to updating these variables to reflect new data, this memorandum discusses the revisions in VMT projections which may be required to reflect the TCP.

The results are therefore framed to answer the following questions:

- What is the effect of the Transportation Control Plan on projected emissions with and without the 3–A system?
- What is the effect of individual TCP control measures on the 3–A and resultant projected VMT and emissions?
- Is gas rationing required to maintain the standards with or without the 3–A?

1.3 REPORT ORGANIZATION

This Introduction includes a brief description of the background and purpose of the BREIS. A detailed description of the alternatives in BREIS, which provide the baseline conditions for this current analysis, is also given.

Section 2 describes the general approach to the analysis and the detailed data base and assumptions for each of the major source categories affected by the TCP.

The analysis results are described in Section 3. Primary emphasis is given to a comparison of the hydrocarbon emission reductions obtained with the TCP to the 70 percent reduction required to meet the photochemical oxidant standard. In addition, emissions summaries are given for the alternatives.

Section 4 briefly describes the relationship of this analysis to other studies in the area and suggests the direction for further study.

The Appendix contains detailed technical discussions, reference data, and sample computer input/output tables.

LIST OF REFERENCES—INTRODUCTION

1. Urban Design Concept Associates. "Transportation, Environmental, and Cost Summary—An Evaluation of Three Concepts for Expressway Routes in Baltimore City," 1968. (Supported by a series of reports on route segments).

2. Wilbur Smith and Associates. "Baltimore Metropolitan Area Transportation Study," 1964.

   Alan M. Voorhees & Associates, Inc. "Travel Forecasting and Patronage Estimates for Baltimore Region Rapid Transit System," July 1968.

   Alan M. Voorhees & Associates, Inc. "Update of Patronage, Revenue, and Operating Costs for Phase I, Baltimore Rapid Transit System," January 1971.

3. Movement Against Destruction v. Volpe, Civil N. 72-1041-M (D. Md., filed June 22, 1973).

4. U.S. Environmental Protection Agency. "Approval of Transportation Control Plan," <u>Federal Register</u>, Vol. 38, No. 238, December 12, 1973.

2.0 METHODOLOGY AND ASSUMPTIONS

The analysis required to determine the effects of the TCP serves as an update to the BREIS air quality analysis and incorporates new data and revised assumptions. The analysis is also illustrative of the application of BREIS as a "data base and data resource document" to be used to consider regional policy implications.

The TCP as promulgated is intended to meet the air quality standards by May 31, 1977.(1) However, to date, none of the measures described is completely implemented, and implementation of the more severe or costly measures is questionable or in litigation.

In view of these considerations and the primary purpose of the analysis, it is not appropriate or cost effective to repeat the detailed "link-by-link" analyses procedures given in BREIS Technical Memorandum No. 3, especially since air quality projections are not a product of this study. Therefore, a simplified regional analysis approach is applied to the BREIS data base to determine the effects of the TCP.

The analysis approach and detailed assumptions used are defined in the following discussion.

2.1 GENERAL APPROACH

The general approach to the analysis was structured as follows:

- Develop emission estimates for each alternative for carbon monoxide (tons/year), hydrocarbons (tons/peak period), oxides of nitrogen (tons/year)
- Apply TCP control strategies to 1983 and 1995 alternatives and estimate resultant regional emissions
- Determine the percent reduction in emissions obtained
- Compare the hydrocarbon reduction obtained to the 70 percent reduction required to meet the oxidant standard

The impacts of the controls are assessed for several alternatives:

Alternative	Year	Assumptions
1[1]	1972	Existing
3[2]	1983	3–A complete, Phase 1 of Rapid Transit Plan complete, other GDP highways as existing and programmed
5[2]	1983	No 3–A beyond what is existing and under construction, other assumptions as in Alternative 3

Alternative	Year	Assumptions
6	1995	3–A complete, Rapid Transit complete as in the GDP, other highways as in the GDP
9	1995	No-build, no 3–A beyond that existing and under construction, other highways as existing or under construction, Rapid Transit as in the GDP

[1]Derived from BREIS Alternative 1 (1970)

[2]Derived from BREIS Alternatives 3 and 5 (1980)

The study area is shown in Figure 2–1. The Baltimore Metropolitan Area Transportation Study (BMATS) area is implied wherever "regional" emissions or VMT are referred to.

The Transportation Control Plan measures evaluated include, in addition to the Federal Motor Vehicle Control Program (FMVCP):

- Inspection and maintenance
- Retrofit strategies
- Traffic flow improvements
- VMT reduction measures: exclusive bus and carpool lanes, carpool locator, bikeway program, parking restrictions, parking management
- Gasoline distribution limitations

The additional stationary source controls promulgated by Maryland on October 3, 1973, include controls on:

- Industrial process heating
- Solvent usage
- Gasoline storage and handling

The analysis results assume the control measures are applied in the order defined in the TCP Technical Support Document prepared by EPA.(4) This assumes gas rationing is applied last, up to the amount required to meet the 70 percent hydrocarbon reduction. In order to evaluate the contribution of each measure to the total reduction required, each measure is also evaluated independently.

The stationary source controls and FMVCP are applied first to obtain the projected emissions without the TCP. The TCP control measures are then applied in order, as suggested by the Federal Register and the Technical Support Document.(1,4)

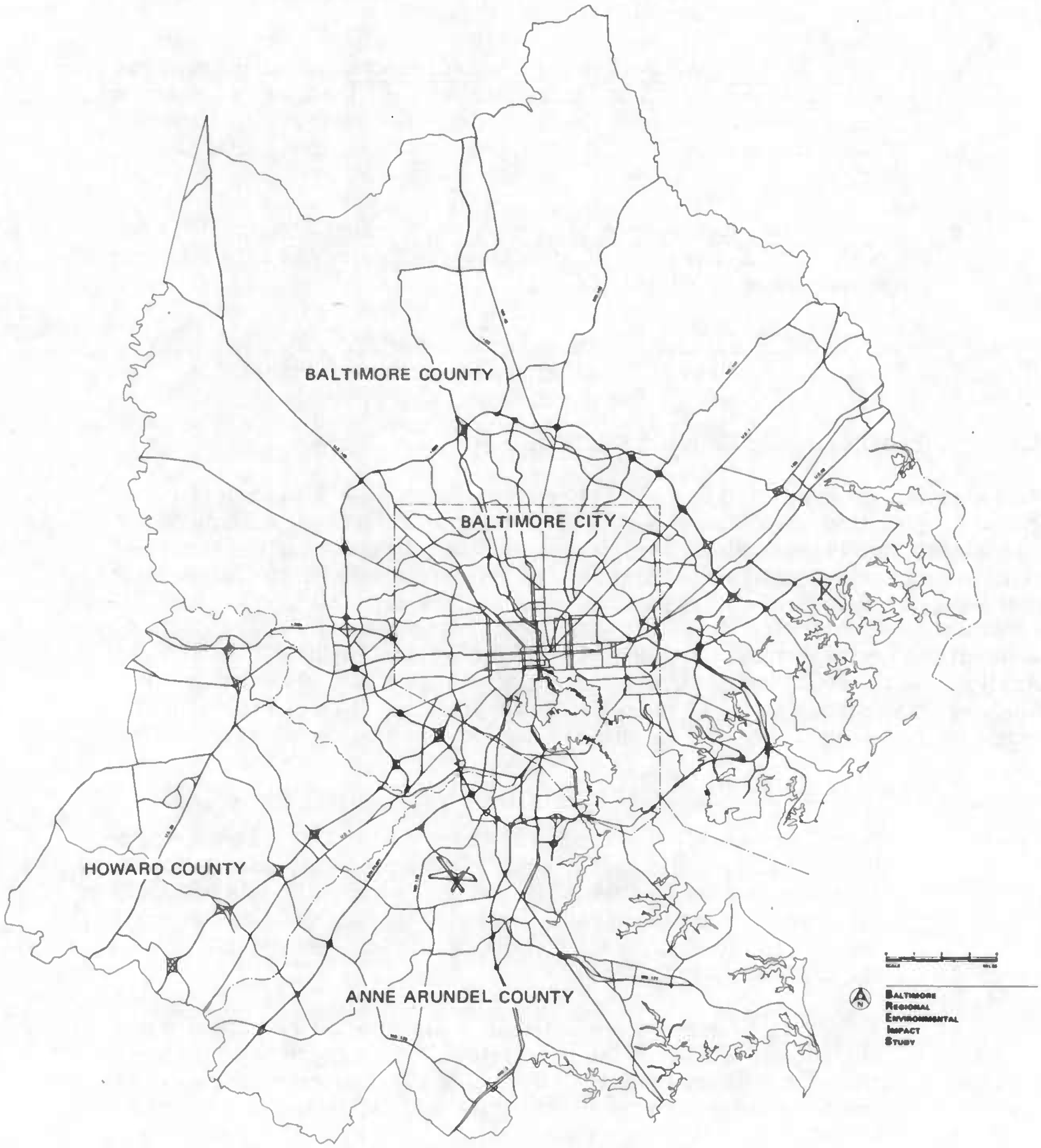

Figure 2-1. BMATS Study Area

The effectiveness of each measure has been determined using the following sources for all measures, except bus lanes and carpool programs:

- Compilation of Air Pollutant Emission Factors, AP–42–Supplement 5, U.S. EPA, unreleased draft, March 1975. (At the time of the study, this document was authorized for use; it has subsequently been revised, but the revisions do not appear to substantively alter the results.)

- Heavy-Duty Retrofit—A Status Report, Norman Friberg—City of New York, Department of Air Resources, September 1974 (and correspondence March 1975).

- Technical Support Document for the Transportation Control Plan for the Baltimore Interstate Region, U.S. EPA, draft report, March 1974.

2.2 DISCUSSION OF ASSUMPTIONS APPLIED

This analysis was conducted at a time of relative uncertainty with respect to regional air pollution control plans such as the Transportation Control Plan and the Air Quality Maintenance Plan. Thus, it was necessary to make certain assumptions in order to estimate air pollutant emissions associated with the future alternatives under consideration. In addition, several changes in the baseline data, the construction schedule for the 3–A system, EPA emission factors, and projection assumptions occurred since the preparation of the original BREIS Air Quality Analysis. In the following paragraphs, the principal assumptions applied in this study are discussed in terms of the rationale for their selection and their significance to the analysis. Some additional assumptions are also discussed in Section 2.3.

2.2.1 General Assumptions

- Base Year — 1972 was used as the base year in this analysis, rather than 1970 which was used in BREIS Technical Memorandum No. 3. This was because EPA used 1972 baseline air quality data in the determination of emission reduction requirements. This change enabled the analysis to incorporate more complete and updated data into the baseline emission inventory.

- 3–A System Construction Schedule — Because of the extended construction schedule for the 3–A system, the expected year of completion was assumed to be 1983 instead of 1980. Corresponding adjustments were made to the other inputs, mainly traffic, as discussed below.

- TCP Control Measures — The TCP control measures were assumed to be applied in order, as suggested in the promulgated plan and the EPA Technical Support Document.(1,4) Gasoline rationing was assumed to be applied last, up to the amount required to meet the 70 percent hydrocarbon reduction by May 31, 1977.

- Effects of State Implementation Plan and Air Quality Maintenance Plan — The emissions projected for 1983 and 1995 in this analysis reflected only existing emission controls and regulations promulgated by the EPA and BAQC. They did not consider the potential emission limitations which may be required by the State Implementation Plan (SIP) and Air Quality Maintenance Plan. The SIP to be revised and the Baltimore Region Air Quality Maintenance Plan to be developed will limit the regional emissions to the levels that the air quality standards will be attained and maintained within the planning periods (40 CFR51). Without considering these potential controls, the analysis tends to overestimate the future emission projections. The effects of this assumption on analysis results will be discussed below.

2.2.2 Assumptions for Stationary Source Emissions

- Estimate of 1983 Emissions Based on 1980 Projections — The 1980 emissions projected in the BREIS Technical Memorandum No. 3 were used as 1983 stationary source emissions in this analysis. The rationale for this is that the 1980 projections originally assumed completion of the 3–A system. With completion of the 3–A system delayed to 1983, it is reasonable to assume the related industrial and stationary source growth would generally reflect a corresponding adjustment.

2.2.3 Assumptions on Mobile Source Emissions

- Vehicle Classification — The vehicle classifications used in the TCP and BREIS Technical Memorandum No. 3 are different from those used in the revised EPA "Compilation of Air Pollutant Emission Factors" (AP–42). The primary difference is related to the gross vehicle weight of heavy-duty vehicles (6,000 lbs. vs. 8,500 lbs. in the later version). The following assumptions were made to adjust the vehicle mix by class to account for the revised classification for estimating mobile source emissions, based on national statistics:
  - The light-duty gasoline truck class includes 2/3 previously defined light-duty vehicles and 1/3 medium-duty vehicles.
  - The heavy-duty gasoline vehicle class was assumed to include 1/3 medium-duty and 2/3 heavy-duty vehicles, as previously defined. (See Table 2–1.)

- Addition of Catalytic Retrofit of Heavy-Duty Gasoline Vehicles — The catalytic retrofit of heavy-duty gasoline vehicles was added to the promulgated control programs for the purpose of this study. This addition was based on the result of a recent study on emission controls on heavy-duty vehicles in New York.(3) This control element was assumed to be applied to 1974 to 1977 models only, as the emissions of post-1977 models will meet the Federal emission standards.

Table 2-1. A Comparison of Previous and New Vehicle Classification

Previous Vehicle Classification[1]		New Vehicle Classification[2]	
Light-duty vehicle:	6,000 lbs. GVW or less	Light-duty gasoline vehicle:	Motor vehicle designated primarily for transportation of persons and having a capacity of 12 persons or less
Medium-duty vehicle:	Greater than 6,000 lbs. or less than 10,000 lbs. GVW	Light-duty gasoline truck:	Gasoline-powered trucks having 8,500 lbs GVW or less
Heavy-duty vehicle:	10,000 lbs. GVW or greater	Heavy-duty gasoline vehicle:	Gasoline-powered vehicle with GVW more than 8,500 lbs.
		Heavy-duty diesel vehicle:	Diesel vehicles with 6,000 lbs GVW or greater

[1] This classification was used in TCP promulgated by the U.S. EPA.

[2] This classification is used in the newly-revised U.S. EPA publication AP-42-5G, "Compilation of Air Pollutant Emission Factors."

- Estimate of 1972 and 1983 Travel Characteristics — Due to the adjusted baseline year and the anticipated year of completion for the 3–A system, several assumptions were made in order to extrapolate the 1972 and 1983 travel parameters from the previous BREIS work. The basic assumptions, which were developed in coöperation with the Baltimore Regional Planning Council, include:
  - VMT per vehicle over short time periods will be stable so long as there are no major changes in the highway system.
  - System average speed is stable over short time periods in the absence of major system changes.
  - Regional average trip length is stable without major system changes.

  Based on these assumptions, the 1972 and 1983 VMT can be extrapolated from the 1970 and 1980 data by considering the growth in vehicle population.

- Assumptions on Traffic Characteristics:
  - The 6–9 a.m. VMT was assumed to be equal to the two-hour p.m. peak period, which was 20 percent of 24-hour VMT based on the BREIS work.
  - The percentages used for splitting VMT into VMT by vehicle types are presented in Table 2–2. These percentages were developed based on a detailed analysis discussed in Appendix B.

- Based on the estimated average trip lengths and the EPA definition for different vehicle operational phases,(2) the percentage of vehicles operating in cold start, hot start, and hot stabilized conditions used in emission factor calculations were assumed as follows:
  - All work trips are in a cold start condition.
  - 50 percent of all non-work trips made in non-catalytic vehicles are in a cold start condition.
  - 75 percent of all non-work trips made in catalytic vehicles are in hot start condition.
  - 25 percent of all non-work trips made in catalytic vehicles are in cold start condition.

  From these assumptions, the composite percentages for total VMT can be obtained by weighting the number of work and non-work trips. Therefore, the composite emission factors can be estimated based on the calculated composite percentages.

2.3 DETAILED METHODOLOGY

The methodology, assumptions, and data used to obtain projected traffic and emissions for the 1972, 1983, and 1995 uncontrolled and controlled alternatives are described in the following subsections.

Table 2-2. VMT Split by Vehicle Type

Vehicle Type	Interzonal						Intrazonal[1]		
	1972		1983		1995				
	24-Hour	Peak (6-9 a.m.)	24-Hour	Peak (6-9 a.m.)	24-Hour	Peak (6-9 a.m.)	1972	1983	1995
LD Auto, gas	88.3	91.2	88.0	91.0	87.7	90.8	57.4	66.0	68.9
LD Trucks, gas	4.6	3.1	4.7	3.2	4.8	3.2	41.9	33.5	30.7
HD Trucks, gas	5.1	4.1	5.25	4.2	5.4	4.3	0.7	0.5	0.4
HD Truck, diesel (excluding buses)	2.0	1.6	2.05	1.6	2.1	1.7	--	--	--

[1]The peak (6-9 a.m.) split was assumed to be the same as 24-hour split.

2.3.1 Stationary Source Emissions Inventory

In preparation of this document, the BREIS Technical Memorandum No. 3 stationary source inventories have been updated to include new data received from Maryland Bureau of Air Quality Control (BAQC)(10,11) and the new BAQC source control revisions.(1)

Table 2–3 is the revised hydrocarbon emissions inventories for non-motor vehicle sources. The hydrocarbon emissions projections for 1983 and 1995 reflect controls on emissions from industrial process heating, solvent usage, and gasoline storage and handling promulgated by the EPA and BAQC for the Baltimore Air Quality Control Region (AQCR). Emissions projections estimates for these categories were obtained from the BAQC. This reflects present controls plus regulations which require major source emissions to remain at their present level and prohibit the addition of new major sources. The row entitled "Gasoline Storage and Handling" reflects requirements for the installation of vapor recovery devices on underground tanks and on gasoline pumps.

The baseline and projected carbon monoxide emissions inventories are given in Table 2–4. The 1972 stationary source inventory is revised to reflect new data from BAQC on miscellaneous gasoline engines and other sources as indicated.

Table 2–5 is the revised nitrogen oxide (NO_x) Inventory. The nitrogen oxide emissions reflect updated figures received from the Maryland Bureau of Air Quality Control. The emissions figures for the diesel and shipping category in the 1971 inventory apparently were too low. Power plant emissions projections are revised as a result of revised future fuel usage estimates by Baltimore Gas and Electric. The diesel and shipping estimates are also revised on the basis of current proportions, after subtracting airport emissions from Anne Arundel County.

In adjusting the 1980 projected emissions to 1983, consideration must be given to the fact that the 1980 projections originally assumed completion of the 3–A system. With completion of the 3–A delayed, it is reasonable to assume the related industrial growth will also be delayed. Therefore, the 1980 projections are used as a conservative estimate of 1983 stationary source emissions.

2.3.2 Uncontrolled Motor Vehicle Emissions

Uncontrolled motor vehicle emissions refer to pollutant concentrations exhausted from motor vehicles which are without any controls, including inspection/maintenance and retrofit. The recently revised methodology provided in Appendix D to AP–42 was used for the study.(2)

All motor vehicles in the Baltimore region are classified into four categories: light-duty gasoline vehicles, light-duty gasoline trucks, heavy-duty gasoline vehicles, and heavy-duty diesel vehicles. According to the EPA's definition, light-duty gasoline vehicles are the gasoline-powered motor vehicles designated primarily for transportation of persons and have a capacity of 12 persons or less. This category includes primarily passenger cars. The light-duty gasoline trucks refer to the gasoline-powered trucks with a gross vehicle weight of 8,500 pounds or less. This category of trucks is used primarily for personal transportation rather than commercial use.

Table 2-3. Baseline (1972) and Projected 6 to 9 A.M. Summer Hydrocarbon Emissions from Non-Highway Sources, Tons/3 Hours, BMATS Area

Source Category	1972[a] Existing	1983[b] Alt. 3	1983[b] Alt. 5	1995[c] Alt. 6	1995[c] Alt. 9
Power Plants[1]	0.62	0.65	0.65	0.71	0.71
Industrial Process[2]	0.72	0.72	0.72	0.72	0.72
Solvent Usage[2]	5.72	3.88	3.88	3.88	3.88
Gasoline Storage[3] and Handling	3.90	1.58	1.56	2.14	1.79
Refuse[4]	0.15	0.11	0.11	0.14	0.14
Other Transportation[5]	2.37	3.05	3.05	4.33	4.33
Total	13.48	9.99	9.97	11.92	11.57
Metric Tons	(12.23)	(9.06)	(9.04)	(10.81)	(10.50)

Assumes:

[1]1 percent per year increase due to increased fuel use

[2]'72 and '73 HC regulation will reduce base year emissions and maintain no growth increase in this category

[3]All sources controlled by May '77 at 90 percent or better. Growth at 3 percent per year with increased consumption factored into total

[4]Increase with population; no new incinerators; municipal incinerators controlled at best available rate

[5]Trains, ships, etc., increase at 1 percent per year; aircraft increase at 4 percent per year after full control in 1972; miscellaneous increases at 3 percent per year uncontrolled

(a) Primary source for 1972 data is "Four Alternative Strategies Document," BAQC

(b) 1980 projections are used to represent 1983 due to RPC data on decreased population growth rate and delayed 3-A completion. Projections agree with "Four Alternative Strategies Document," except as noted

(c) "Four Alternative Strategies" growth rate assumptions used except as noted

Table 2-4. Projected Non-Highway Sources Emissions of Carbon Monoxide, Tons/Year, BMATS Study Area

Source Category	1972 (a)	1983 (b)		1995	
	Base	Alternative 3 Complete 3-A	Alternative 5 No 3-A	Alternative 6 Complete 3-A and GDP Improvements	Alternative 9 No 3-A or other GDP Improvements
Mobile					
Misc. gas engines[1]	13,000	13,000	13,000	13,000	13,000
Other Transportation	11,700	13,630	13,630	15,990	15,990
Stationary					
Point[2]	61,550	40,630	40,630	51,080	51,080
Area	7,500	8,920	8,850	11,030	10,410
Total	93,750	76,180	76,110	91,100	90,480
Metric Tons	(85,049)	(69,109)	(69,047)	(82,647)	(82,081)

[1]New estimate by BAQC

[2]Includes 28,840 T/yr. for Bethelehem Steel with no growth assumed. New BAQC estimates indicate this may be as high as 96,000 T/yr. However, it is emitted at too low concentration to burn. Therefore, this figure should not be used for rollback purposes. A revised figure for rollback is required.

(a) **Primary source for 1972 CO emissions is "Four Alternative Strategies Document" revised due to power plant, miscellaneous gasoline, and point source projections.**

(b) 1980 projections are used to represent 1983 due to decreased population growth rate and delayed 3-A system completion.

Table 2-5. Projected Non-Highway Sources Emissions of Oxides of Nitrogen, Tons/Year, BMATS Study Area

Source Category	1972 [(a)]	1983 [(b)]		1995	
	Base	Alternative 3 Complete 3-A	Alternative 5 No 3-A	Alternative 6 Complete 3-A and GDP Improvements	Alternative 9 No 3-A or other GDP Improvements
Mobile					
Other Transportation	14,500	16,795	16,795	20,762	20,762
Stationary					
Point [1]	75,690	53,475	53,475	64,490	64,490
Area	6,700	7,800	7,730	9,640	9,100
Total	96,890	78,070	78,000	94,892	94,352
Metric Tons	(87,896)	(70,825)	(70,763)	(86,085)	(85,596)

[1]Revised to account for new growth projections

(a) Primary source of data--BREIS Tech Memo #3 as revised for point source projections

(b) 1980 projections are used to represent 1983 due to decreased population growth rate delayed 3-A system completion

The heavy-duty gasoline vehicles include gasoline-powered vehicles weighing more than 8,500 pounds gross vehicle weight. It may consist of trucks, buses, and special purpose vehicles such as motor homes. The heavy-duty diesel vehicles refer to all diesel vehicles weighing over 6,000 pounds gross vehicle weight. It is primarily comprised of trucks and buses.

The methodology used to estimate motor vehicle emission factors in the Baltimore region was based on that of the Federal Test Procedure.(12) Because of the differences in Federal exhaust emission standards, engine system, and type of fuel used, the emission factor for each category of vehicles is different. Therefore, emissions for each category of vehicles were to be estimated separately. To avoid tedious calculations, a computer program was developed based on the methodology of the Federal Test procedure to compute the emission factors for each category of vehicles. The detailed methodology incorporated in the computer program is discussed in Appendix A.

2.3.3 Controlled Motor Vehicle Emission Factors

The Transportation Control Plan for the Metropolitan Baltimore region includes retrofit and inspection/maintenance programs to reduce motor vehicle emissions. The following paragraphs discuss the effects of these control measures on the emission factors for each vehicle category.

2.3.3.1 Motor Vehicle Emission Factors with Retrofit — The retrofit programs promulgated by the U.S. Environmental Protection Agency are summarized in Table 2–6. These control measures are applied to specific vehicle classes such as light-duty, medium-duty, or heavy-duty vehicles. However, the revised motor vehicle emission factors are based on a new vehicle classification. A comparison of the previous to the new vehicle classification is presented in Table 2–1. It can be seen that medium-duty vehicles are not included in the new vehicle classes. Thus, to apply the promulgated control measures to new vehicle classes, several assumptions must be made:

- Based on nationwide statistics, the class of "light-duty gasoline truck" includes 2/3 of previously defined light-duty vehicles and 1/3 of medium-duty vehicles.
- The class of "heavy-duty gasoline vehicle" was assumed to include 1/3 of medium-duty and 2/3 of heavy-duty vehicles as previously defined.

On the basis of these assumptions, the application of retrofit programs to new vehicle classes can be determined. Table 2–7 shows the applicability of the retrofit measures to each new vehicle class. Therefore, the percent reduction of each pollutant emission resulting from each control element (as shown in Table 2–7) can be applied to the new vehicle classes.

The individual controlled vehicle emission factors were used to calculate the composite controlled emissions for a specific calendar year. Sample controlled emission factors for each vehicle class and model year vehicle may be found in the computer printouts in Appendix A.

Table 2-6. The Promulgated Retrofit Control Measures

Control Measure	Applicability	Percent Reduction CO	Percent Reduction HC
VSAD Retrofit	Pre-1968 LDV's	9	25
Catalytic Retrofit (L)[1]	75% of 71-74, All 75	50	50
Catalytic Retrofit (M)[1]	75% of 71-74, All 75	50	50
Air/Fuel Retrofit (L)[1]	All 68-70, 25% 71-73	40	25
Air/Fuel Retrofit (M)[1]	All pre-71's, 25% 71-73	15	15
Air/Fuel Retrofit (H)[1,2]	100% 71-73	40	20
Catalytic Retrofit (H)[1,2]	100% 74-77	90[3]	90[3]

[1] Previous Definition:
LDV: $GVW \leq 6000$ #
MDV: $6000\# < GVW \leq 10{,}000\#$
HDV: $10{,}000\# < GVW$

[2] This measure is added to the retrofit programs for the purpose of this study. The percent reduction is based on the result of recent study conducted by Bureau of Motor Vehicle Pollution Control, Environmental Protection Administration, The City of New York, March 1975.

[3] 90 percent reduction for the 1st year; 65 percent reduction 2nd year; 43 percent 3rd year. Life time of this catalytic retrofit is assumed to be 3 years only.

Table 2-7. Application of Retrofit to New Vehicle Classes

New Vehicle Classification	Application	
Light-duty gasoline vehicle	75 percent	with catalytic retrofit (L[1])
	25 percent	with air/fuel retrofit (L[1])
Light-duty gasoline truck[2]	67 percent	with catalytic retrofit (L[1]) or air/fuel retrofit (L[1])
	33 percent	with catalytic retrofit (M[1]) or air/fuel retrofit (M[1])
Heavy-duty gasoline vehicle[3]	33 percent	with catalytic retrofit (M[1]) air/fuel retrofit (M[1])
	67 percent	with catalytic retrofit (H[1]) air/fuel retrofit (H[1])

[1]Previously defined

[2]On the basis of numbers of vehicles. Nationwide, the light-duty gasoline truck includes two-thirds of previously defined LDV, and one-third of previously defined MDV.

[3]This category is assumed to be including one-third of MDV and two-thirds of HDV of previous definition.

It should be noted that catalytic retrofit of heavy-duty gasoline vehicles was added to the promulgated programs for the purpose of this study. This addition was based on the result of a recent study on emission controls on heavy-duty vehicles in New York.(3) It indicates that an oxidation catalyst can reduce 90 percent of both CO and HC during the initial year, and the effectiveness of this control may decline to 45 percent after 25,000 miles of operation. This control element was assumed to be applied to '74, '75, '76, and '77 models only, as the emission factors of post-1977 models will meet standards. The air-fuel retrofit device studied in New York was found to be applicable to pre-1974 models and most effective in older models.

2.3.3.2 Motor Vehicle Emission Factors with Inspection/Maintenance Program — The promulgated Transportation Control Plan includes a regulation requiring a dynamic mode inspection of all light-duty, medium-duty, and heavy-duty vehicles. The emission reductions for inspection/maintenance programs are summarized in Table 2–8. The percent reduction of both CO and HC for light-duty gasoline vehicles and trucks was obtained from Reference 2. The deterioration factors of inspection/maintenance programs are listed below:

- A 10-percent reduction in CO and HC can be applied to all model year vehicles starting the year I/M is introduced.
- Deterioration following the initial 10-percent reduction is assumed to follow the schedules below:

	HC	CO
Pre-1975 vehicles	2 percent/year	2 percent/year
1975 and later vehicles	12 percent/year	7 percent/year

- This deterioration continues until a vehicle is ten years old and remains stable thereafter. No catalyst replacement is assumed.
- NO_x emissions are assumed not to be affected by I/M.

The credit for inspection/maintenance program on heavy-duty emissions was not given in the Transportation Control Plan due to insufficient information. The percent reduction of both CO and HC for heavy-duty vehicles was obtained from Reference 3. The deterioration factors of this control element were assumed to be the same as those of light-duty gasoline vehicles.

2.3.4 Uncontrolled Traffic Parameters

The travel data required for obtaining highway emissions in BMATS are the following:

- BMATS VMT by vehicle type
- BMATS average speed by vehicle type
- Trips per automobile per day and miles per automobile per day
- Cold start, hot start percentages

Table 2-8. Credit for Inspection/Maintenance Program

Measure	Applicability	Percent Reduction CO	HC
I/M	All light-duty gasoline vehicles	10[1]	10[1]
	All light-duty gasoline trucks	10[1]	10[1]
IPFIT[2]	All heavy-duty gasoline vehicles	10[1]	30[1]

[1]This is initial reduction--rederioration factors are discussed in text. Sources from references (2) and (13).

[2]Idle plus Fast Idle Test.

The following paragraphs make explicit the data, assumptions, and methodology used in obtaining the travel data for the base year (1972) and Alternatives 3 and 5 in modified forecast year 1983 and Alternatives 6 and 9 in forecast year 1995.

In the basic BREIS work the base year used was 1970 and the forecast years were 1980 and 1995. In the absence of full simulation, a reasonable process is required to estimate the travel parameters for 1972 and 1983. This process was developed in cooperation with the Regional Planning Council.

The problem is complex, since the simulation process accounts for many variables. VMT is a product of total travel, mode choice, trip length, system speed, etc. To arrive at estimates, therefore, one very basic simplifying assumption was made:

- VMT per vehicle over short time periods will be stable so long as there are no major changes in the highway system.

It was also assumed that:

- System average speed is stable over short periods in the absence of major system changes.
- Average trip length is stable in the absence of major system changes.

Based on these assumptions, the 1970 system speed and average trip length were used for 1972. The auto driver trips and the automobile ownership in BMATS was used to obtain the number of trips per automobile per day. Average trip length and trips per automobile per day were used to obtain miles of travel per automobile per day. 1972 VMT was obtained as:

$$VMT_{72} = \frac{VR_{72}}{VR_{70}} \times VMT_{70}$$

where:

VMT_{72}	=	VMT in 1972
VR_{72}	=	vehicle registrations in 1972
VR_{72}	=	vehicle registrations in 1970
VMT_{70} 1970	=	sum of interzonal and intrazonal VMT in 1970 (obtained from BREIS work)

For 1983 estimates the problem is complicated by the fact that the 3–A system is now estimated for completion in 1983, rather than 1980 as assumed in the BREIS analysis. In addition, the population is not growing as rapidly as forecast and the level previously assumed for 1980 is now expected to be reached in 1983. Due to falling family size, however, automobiles per person is growing more rapidly than expected.

The growth in VMT due to increased auto ownership will counteract the decrease due to decreased population growth rate. This will result in an "apparent" growth for 1980 to 1983 VMT equivalent to results obtained by linear interpolation of BREIS 1980 and 1995 VMT estimates. 1983 VMT estimates were obtained as follows:

$$VMT_{83} = VMT_{80} + \frac{3}{15} (VMT_{95} - VMT_{80})$$

where:

VMT_{83} = VMT in 1983

VMT_{80} = VMT in 1980 (obtained from BREIS for Alternatives 3 and 5)

VMT_{95} = VMT in 1995 (obtained from BREIS for Alternatives 6 and 7)

The 1983 system speeds and average trip lengths were assumed to be the same as for 1980. The number of daily trips per automobile and the daily miles of travel per automobile were developed similarly to the development for 1972.

The VMT, speed, and average trip length for 1995 alternatives were obtained from BREIS. Average daily automobile trips and average daily automobile miles of travel were calculated as for 1972.

An estimate of VMT occurring in the morning (6-9 a.m.) peak period was required for obtaining hydrocarbon emissions. It was observed from the diurnal traffic pattern in Baltimore region that the percent of ADT occurring in the 6-9 a.m. period was approximately the same as that occurring in the two-hour p.m. peak period. It was assumed that the average trip lengths in the morning and evening peak periods are the same; hence the VMT occurring in the three-hour morning period will be the same as the two-hour p.m. peak period. The 6-9 a.m. VMT (or two-hour p.m. peak period) was 20 percent of 24-hour VMT based on the BREIS work.

Percentages were developed for splitting VMT into VMT by vehicle types (excluding buses which were estimated independently in BREIS) and are presented in Table 2-9. The procedure for the development of these percentages is presented in Appendix B.

As discussed previously, the percentage of vehicles (VMT) that are operating on cold conditions and those in hot start-up conditions were assumed as follows:

- All work trips are in a cold start condition.
- 50 percent of all non-work trips made in non-catalytic vehicles are in a cold start condition.
- 75 percent of all non-work trips made in catalytic vehicles are in hot start condition.
- 25 percent of all non-work trips made in catalytic vehicles are in cold start condition.

Table 2-9. VMT Split by Vehicle Type

	Interzonal						Intrazonal[1]		
	1972		1983		1995				
Vehicle Type	24-Hour	Peak (6-9 a.m.)	24-Hour	Peak (6-9 a.m.)	24-Hour	Peak (6-9 a.m.)	1972	1983	1995
LD Auto, gas	88.3	91.2	88.0	91.0	87.7	90.8	57.4	66.0	68.9
LD Trucks, gas	4.6	3.1	4.7	3.2	4.8	3.2	41.9	33.5	30.7
HD Trucks, gas	5.1	4.1	5.25	4.2	5.4	4.3	0.7	0.5	0.4
HD Truck, diesel (excluding buses)	2.0	1.6	2.05	1.6	2.1	1.7	--	--	--

[1]The peak (6-9 a.m.) split was assumed to be the same as 24-hour split.

Total trips and average trip lengths were split up into work and non-work trip purposes. Cold and hot start percentages for work and non-work trip purposes were developed from trip lengths. These percentages were weighted by the number of trips (work and non-work) to obtain composite percentages.

The results of the travel analysis are presented in Tables 2–10 through 2–14 for the base year (1972), and 1983 and 1995 alternatives.

2.3.5 VMT Reduction Measures

The effectiveness of VMT reduction measures is dependent upon two primary variables:

- Exposure — the percent of VMT exposed to the measure
- Capture — the percent of exposed VMT which can be expected to be reduced or shifted to other modes

The overall VMT reduction resulting from each measure can be calculated as follows:

- Total Reduction = Exposure x Capture

The general assumptions and methodology for determining the exposure and capture rate for each VMT measure are described below.

2.3.5.1 Bus and Carpool Lane — Preferential lanes for high-occupancy vehicles are established in all radial corridors. Based on the assumption that in a.m. peak traffic period (6-9 a.m.) high-occupancy vehicles get a five-minute relative travel time advantage compared to the null situation, the corresponding exposure and capture rates are calculated in Appendix C. The estimated resulting VMT reduction of these measures are summarized in Table 2–15.

2.3.5.2 Carpooling — The promulgated carpooling measure includes employer-based carpool matching program, carpool promotion, and incentives. Based on a detailed analysis discussed in Appendix C, the resulting VMT reduction is also presented in Table 2–15.

2.3.5.3 Parking Restrictions and Parking Management — These two programs are required to ensure the effectiveness of the other VMT reduction measures. However, no credit was taken by EPA for any additional reduction in VMT.[1] Current parking management program studies in California indicate some additional VMT reduction can be expected in the long term. However, investigation of this effect in Baltimore would require extensive land use and economic factor analysis beyond the scope of this study. Therefore, a "worst case" estimate of no additional VMT reduction was assumed for these measures.

[1] See EPA correspondence in Appendix D.

Table 2-10. Base Year (1972) Travel Parameters

Vehicle Type	24-Hour VMT	Peak (6-9 a.m.) VMT	24-Hour Speed	Peak (6-9 a.m.) Speed	Trips Per Vehicle Day	Miles Per Vehicle Day	Average Trip Length (miles)
Auto	15,512,770	3,202,670	22.2	19.9	3.43	24.7	7.2
LDT	887,910	125,280	22.2	19.9			
HDT, gas	890,620	143,260	22.2	19.9			
HDT, dies.	348,700	55,790	22.2	19.9			
BUS	83,400	15,920	22.2	19.9			
TOTAL	17,723,400	3,542,920					

	24-Hour (percent)	Peak (6-9 a.m.) (percent)
Cold Start (Non Catalyst)	17.2	18.5
Cold Start (Catalyst)	--	--
Hot Start (Catalyst)	--	--

Table 2-11. Alternative 3 (1983) Travel Parameters

Vehicle Type	24-Hour VMT	Peak (6-9 a.m.) VMT	24-Hour Speed	Peak (6-9 a.m.) Speed	Trips Per Vehicle Day	Miles Per Vehicle Day	Average Trip Length (miles)
Auto	23,324,700	4,822,490	22.9	19.8	3.12	25.3	8.1
LDT	1,344,750	190,180	22.9	19.8			
HDT, gas	1,380,160	220,900	22.9	19.8			
HDT, dies.	538,300	84,020	22.9	19.8			
BUS	99,080	19,820	22.9	19.8			
TOTAL	26,686,990	5,337,410					

	24-Hour (percent)	Peak (6-9 a.m.) (percent)
Cold Start (Non Catalyst)	15	16
Cold Start (Catalyst)	19	19
Hot Start (Catalyst)	31	29

Table 2-12. Alternative 5 (1983) Travel Parameters

Vehicle Type	24-Hour VMT	Peak (6-9 a.m.) VMT	24-Hour Speed	Peak (6-9 a.m.) Speed	Trips Per Vehicle Day	Miles Per Vehicle Day	Average Trip Length (miles)
Auto	22,877,720	4,730,030	21.5	19.5	3.12	25.3	8.1
LDT	1,322,210	187,200	21.5	10.5			
HDT, gas	1,353,370	216,600	21.5	19.5			
HDT, dies.	527,800	82,390	21.5	19.5			
BUS	99,080	19,820	21.5	19.5			
TOTAL	26,180,180	5,236,040					

	24-Hour (percent)	Peak (6-9 a.m.) (percent)
Cold Start (Non Catalyst)	15	16
Cold Start (Catalyst)	19	19
Hot Start (Catalyst)	31	29

Table 2-13. Alternative 6 (1995) Travel Parameters

Vehicle Type	24-Hour VMT	Peak (6-9 a.m.) VMT	24-Hour Speed	Peak (6-9 a.m.) Speed	Trips Per Vehicle Day	Miles Per Vehicle Day	Average Trip Length (miles)
Auto	28,634,190	5,926,970	25.1	21.9	3.04	25.2	8.3
LDT	1,694,070	235,520	25.1	21.9			
HDT, gas	1,745,000	277,980	25.1	21.9			
HDT, dies.	677,880	109,750	25.1	21.9			
BUS	119,000	23,800	25.1	21.9			
TOTAL	32,870,140	6,574,020					

	24-Hour (percent)	Peak (6-9 a.m.) (percent)
Cold Start (Non Catalyst)	15	16
Cold Start (Catalyst)	18	18
Hot Start (Catalyst)	30	28

Table 2-14. Alternative 9 (1995) Travel Parameters

Vehicle Type	24-Hour VMT	Peak (6-9 a.m.) VMT	24-Hour Speed	Peak (6-9 a.m.) Speed	Trips Per Vehicle Day	Miles Per Vehicle Day	Average Trip Length (miles)
Auto	23,988,800	4,965,130	17.3	15.4	2.97	22.9	7.7
LDT	1,435,750	200,770	17.3	15.4			
HDT, gas	1,459,550	232,520	17.3	15.4			
HDT, dies.	566,900	91,780	17.3	15.4			
BUS	119,000	23,800	17.3	15.4			
TOTAL	27,570,000	5,514,000					

	24-Hour (percent)	Peak (6-9 a.m.) (percent)
Cold Start (non Catalyst)	15	16
Cold Start (Catalyst)	20	20
Hot Start (Catalyst)	33	31

Table 2-15. Effect of VMT Reduction Measures

VMT Reduction Measure	1983 Percent VMT Reduction 6-9 a.m.	1983 Percent VMT Reduction 24-hour	1995 Percent VMT Reduction 6-9 a.m.	1995 Percent VMT Reduction 24-hour
Preferential Lanes				
Shift to Buses	.18 to .41	.07 to .16	.24 to .55	.24 to .55
Shift to Carpools	.55 to 1.12	.22 to .45	.73 to 1.5	.73 to 1.5
Employer-Based Carpool Incentives	.68 to 1.35	.27 to .54	.09 to 1.8	.09 to 1.8
TOTAL	1.41 to 2.88	.56 to 1.15	1.87 to 3.85	1.87 to 3.85

2.3.5.4 Bikeway Program — Although a bikeway program was considered as part of the Transportation Control Plan, the expected reduction in VMT on a regional basis is considered by EPA[1] to be negligible. Microscale analysis in the vicinity of planned bikeways may indicate some impact.

2.3.6 Traffic Flow Improvement

In their Technical Support Document, EPA assumed that traffic flow improvement measures including TOPICS related programs could provide the following speed improvements:

- One percent increase in 24-hour average regional speeds
- Ten percent increase in 6-9 a.m. average regional speeds

No induced VMT was assumed to result from the improved flow due to the vehicle restraint measures (parking restrictions, parking management, gasoline rationing) which are imposed to maintain the effectiveness of the other measures.[1]

Applying these assumed effectiveness rates to the 1983 and 1995 projected regional average speeds yields the changes in speed and speed correction factors given in Tables 2–16 and 2–17. These speed correction factors are then applied to the uncontrolled or controlled vehicle emission factors to obtain the adjusted vehicle emission factor and resultant reductions in emissions.

2.3.7 Gasoline Distribution Limitation

As in the EPA Technical Support Document, gas rationing is applied last. The intent is to implement all other reasonable measures before resorting to this program.

It should be recognized that if gas rationing were applied first or even assumed to be already implemented prior to the 1983 or 1995 projection years, the VMT would not grow to the uncontrolled totals shown in Section 2.3.4 and reduction impact of the other measures would change.

The procedure for determining the amount of gasoline distribution limitation, or gas rationing required, is as follows:

(1) Total Allowable HC Emissions

= (1–70 percent peak period HC) x 1972 emissions

= .3 x 45.56 Metric tons

= 13.67 Metric tons/6 to 9 a.m. peak

(2) Total Emissions Remaining After TCP (no gas rationing)

1983 ALT 3 = 20.21 Metric tons (MT/Peak Period)
1983 ALT 5 = 20.14 MT/PP

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[1]See EPA correspondence in Appendix D.

Table 2-16. Speed Changes

	24-Hour Speeds (Regional Average)				
	1972	1983		1995	
		ALT 3	ALT 5	ALT 6	ALT 9
Uncontrolled	22.2	22.9	21.5	25.1	17.3
Traffic Flow (1 percent increase)		23.1	21.7	25.4	17.5

	Peak 6-9 a.m. Speeds (Regional Average)				
	1972	1983		1995	
		ALT 3	ALT 5	ALT 6	ALT 9
Uncontrolled	19.9	19.8	19.5	21.9	15.4
Traffic Flow (10 percent increase)		21.8	21.5	24.1	16.9

Table 2-17. Speed Correction Factor Change

	1972			1993					
				Alternative 3			Alternative 5		
	LDA, LDT	HDG	HDD	LDA, LDT	HDG	HDD	LDA, LDT	HDG	HDD
Uncontrolled, CO, 24-hr.	.991	.908	.791	.851	.977	.752	.910	.829	.912
With Traffic Flow Imp., CO, 24-hr.	-----	-----	-----	.943	.971	.745	.801	.919	.903
Uncontrolled, NO_x, 24-hr.	1.021	1.021	1.090	1.027	1.019	1.102	1.019	1.010	1.079
With Traffic Flow Impl., NO_x, 24-hr.	-----	-----	-----	1.029	1.019	1.109	1.017	1.011	1.090
Uncontrolled, HC, 8-9 a.m.	.999	.999	.930	.993	.992	.934	1.004	1.005	.944
With Traffic Flow Imp., HC, 8-9 a.m.	-----	-----	-----	.925	.913	.973	.939	.929	.994

	1995					
	Alternative 6			Alternative 9		
	LDA, LDT	HDG	HDD	LDA, LDT	HDG	HDD
Uncontrolled, CO, 24-hr.	.799	.810	.873	1.130	1.104	1.003
With Traffic Flow Imp., CO, 24-hr.	.758	.801	.883	1.118	1.084	1.022
Uncontrolled, NO_x, 24-hr.	1.045	1.031	1.139	.982	.989	.992
With Traffic Flow Impl., NO_x, 24-hr.	1.047	1.033	1.142	.984	.999	.984
Uncontrolled, HC, 8-9 a.m.	.822	.908	.870	1.180	1.210	1.039
With Traffic Flow Imp., HC, 8-9 a.m.	.857	.835	.815	1.110	1.128	1.015

1995 ALT 6 = 18.54 MT/PP
1995 ALT 9 = 18.15 MT/PP

(3) Total Emissions Remaining after TCP

Mobile Source	Stationary Source
1983 ALT 3 = 11.15 MT/PP	ALT 3 = 9.06 MT/PP
1983 ALT 5 = 11.10 MT/PP	ALT 5 = 9.04 MT/PP
1995 ALT 6 = 7.73 MT/PP	ALT 6 = 10.81 MT/PP
1995 ALT 9 = 7.65 MT/PP	ALT 9 = 10.50 MT/PP

(4) Additional Tons of Mobile Source HC Emissions Reduction Required

Total Allowable Emissions =

ALT 3 = 20.21 - 13.67 = 6.54
ALT 5 = 20.14 - 13.67 = 6.47
ALT 6 = 18.54 - 13.67 = 4.87
ALT 9 = 18.15 - 13.67 = 4.48

(5) Gas Rationing Required

$$= \frac{\text{Mobile Source emissions reduction required}}{\text{remaining mobile source emissions}}$$

$\text{ALT } 3 = \frac{6.54}{11.15} =$ 58.7 percent (assumes gas rationing required is equivalent to mobile source emissions reduction required or VMT reduction required)

$\text{ALT } 5 = \frac{6.47}{11.10} =$ 58.3 percent

$\text{ALT } 6 = \frac{4.87}{7.73} =$ 63.0 percent

$\text{ALT } 9 = \frac{4.48}{7.65} =$ 58.6 percent

These reductions are also applied to CO emissions to determine the remaining CO emissions after gas rationing.

REFERENCES FOR SECTION 2.0

1. U.S. Environmental Protection Agency. "Approval of Transportation Control Plan," Federal Register, Vol. 38, No. 238, December 12, 1973.

2. U.S. Environmental Protection Agency. Compilation of Air Pollutant Emission Factors, AP–42, Supplement 5G, Appendix D, December 1975.

3. Bureau of Motor Vehicle Pollution Control, the City of New York, Heavy-Duty Vehicle Retrofit, monthly reports.

4. U.S. Environmental Protection Agency. Technical Support Document for the Transportation Control Plan for the Metropolitan Baltimore Interstate Region, draft report, March 1974.

5. R. H. Pratt Associates, Inc. Development and Calibration of the Washington Mode Choice Models, Technical Report No. 8, June 1973.

6. Alan M. Voorhees & Associates, Inc. Guidelines to Reduce Energy Consumption through Transportation Actions, prepared for the Urban Mass Transportation Administration, May 1974.

7. Alan M. Voorhees & Associates, Inc. Short-Range Planning for Reduced Vehicle-Miles of Travel in the SCAG Region, prepared for Southern California Association of Governments, June 1974.

8. Alan M. Voorhees & Associates, Inc. Sensitivity Analysis of Patronage Projections, Technical Working Paper, prepared for the Southern California Rapid Transit District Study of Alternative Transit Corridors and Systems, April 1974.

9. R. H. Pratt Associates, Inc. Low-Cost Transportation Alternatives: A Study of Ways to Increase the Effectiveness of Existing Transportation Facilities, January 1973.

10. Bureau of Air Quality and Noise Control. Four Alternative Strategies Document, 1973.

11. Bureau of Air Quality and Noise Control. Telephone communication, March-April 1975.

12. U.S. Environmental Protection Agency. "Exhaust Emission Standards and Test Procedures," Federal Register, Part II 36(128); 12652-12664, July 2, 1971.

3.0 ANALYSIS OF RESULTS

The methodologies described in Section 2.0 were applied to the vehicle and stationary source projections to obtain projected controlled and uncontrolled emissions. The percent reductions in emissions for each control measure and for the total control strategy were calculated and applied to the 1972 uncontrolled emissions to determine the effect of the control strategy in baseline (1972) and projected (1983, 1995) emissions.

The resultant emissions and emission reductions for carbon monoxide, hydrocarbons, and oxides of nitrogen are described below. The reduction in 6-9 a.m. hydrocarbons achieved by application of the Transportation Control Plan (TCP) is also compared to the estimated 70 percent reduction required to attain the photochemical oxidant standards.

The resultant emissions reductions calculated are based on the most conservative (worst case) estimates of effectiveness of individual control measures as they are specifically applied to the Baltimore study area. The results are indicative of the impact of the TCP on the 3–A system and resultant emissions. The discussion below addresses programs and issues which could alter the results and the limitations of the analysis.

3.1 EMISSIONS INVENTORY

Tables 3–1 to 3–3 summarize the results of the application of the Transportation Control Plan to projected emissions in the BMATS area. The independent percent reduction due to each control measure is given in the tables for CO, HC, and NOx. The total emission reduction for the "TCP minus gas rationing" and the entire TCP is given at the bottom of the table.

It should be noted that the totals consider the interaction of control measures and are therefore not equivalant to the sum of the independent reductions shown in the tables.

3.2 COMPARISON TO STANDARDS

In the Federal Register(1) promulgation of the Transportation Control Plan, EPA estimated a 70 percent reduction in 6 a.m. to 9 a.m. hydrocarbon emissions to be required to attain the photochemical oxidant standard by May 31, 1977. It is also assumed that the measures required to meet the oxidant (hydrocarbon reduction guidelines) standard would be sufficient to meet the carbon monoxide standards. Oxides of nitrogen appear to meet the standards in Baltimore.

Figure 3–1 shows the hydrocarbon emissions with and without the TCP for each alternative considered. The line labeled "hydrocarbon guidelines" is equivalent to 30 percent of the 1972 6 a.m. to 9 a.m. hydrocarbon emissions. The contribution of mobile sources and stationary (non-highway) sources to total emissions is also indicated.

Table 3.1. Summary of Transportation Control Plan Emission Reductions for Peak Period (6 to 9 a.m.) Hydrocarbons

	1983				1995			
	Alternative 3		Alternative 5		Alternative 6		Alternative 9	
	T/P.P.	Percent of Base Yr.	T/P.P.	Percent of Base Yr.	T/P.P.	Percent of Base Yr.	T/P.P.	Percent of Base Yr.
1972 Total peak period emissions/base year	45.56	100.0	45.56	100.0	45.56	100.0	45.56	100.0
Reduction required to reach/maintain NAAQS	31.89	70.0	31.89	70.0	31.89	70.0	31.89	70.0
STATIONARY SOURCES								
1972 Stationary sources (pre-T.C.P.)	12.23	26.8	12.23	26.8	12.23	26.8	12.23	26.8
Stationary sources remaining (T.C.P. growth)	9.06	19.9	9.04	19.8	10.81	23.7	10.50	23.0
MOBILE SOURCES								
1972 mobile sources (pre-T.C.P)	33.33	73.1	33.33	73.1	33.33	73.1	33.33	73.1
Future year mobile sources (w/FMVCP growth, w/o T.C.P.)	13.87	30.4	13.69	30.0	8.79	19.3	8.71	19.1

Table 3-1 (continued)

	1983				1995			
	Alternative 3		Alternative 5		Alternative 6		Alternative 9	
	T/P.P.	Percent of Base Yr.	T/P.P.	Percent of Base Yr.	T/P.P.	Percent of Base Yr.	T/P.P.	Percent of Base Yr.
(a) Reduction, FMVCP minus VMT growth	19.46	42.7	19.64	43.1	24.54	53.8	24.62	54.0
Reduction strategies (b) - (i) [1]:								
(b) Inspection/maintenance (LDV, MDV)	.86	1.9	.85	1.9	.56	1.2	.65	1.4
(c) VSAD retrofit, pre-1968 LDV's	.00	0.0	.00	0.0	.00	0.0	.00	0.0
(d) (1) Air/fuel retrofit, 1971-1973 LDV's	.00	0.0	.00	0.0	.00	0.0	.00	0.0
(2) Air/fuel retrofit, 1971-1973 LDV's [2]	.09	0.2	.24	0.5	.00	0.0	.00	0.0
(e) (1) Catalytic retrofit, 1971-1975, LDV, MDV	.59	1.3	.75	1.6	.00	0.0	.00	0.0
(2) Catalytic retrofit, 1974-1977 HDV's [3]	.46	1.0	.46	1.0	.00	0.0	.00	0.0

Table 3-1 (continued)

	1983				1995			
	Alternative 3		Alternative 5		Alternative 6		Alternative 9	
	T/P.P	Percent of Base Yr.	T/P.P.	Percent of Base Yr.	T/P.P.	Percent of Base Yr.	T/P.P.	Percent of Base Yr.
(f) Air/fuel retrofit, pre-1974 MDV's	.03	0.1	.01	0.0	.00	0.0	.00	0.0
(g) Air/fuel retrofit, HDV's (pre-1974)	.06	0.1	.06	0.1	.00	0.0	.00	0.0
(h) Traffic flow improvements	.55	1.2	.53	1.2	.36	0.8	.32	0.7
(i) VMT measures	.24	0.5	.24	0.5	.16	0.4	.15	0.4
Total reductions due to strategies (b)-(i)	2.72	6.0	2.59	5.7	1.06	2.3	1.06	2.3
(j) Reduction, gasoline distribution limitation	6.54	14.2	6.47	12.0	4.87	10.7	4.48	9.8
Mobile sources remaining without gas distribution limitation	11.15	24.5	11.10	24.4	7.73	17.0	7.65	16.8
Mobile sources remaining with gas distribution	4.61	10.1	4.63	10.2	2.86	6.3	3.17	6.9

Table 3-1 (continued)

	1983				1995			
	Alternative 3		Alternative 5		Alternative 6		Alternative 9	
	T/P.P.	Percent of Base Yr.	T/P.P.	Percent of Base Yr.	T/P.P.	Percent of Base Yr.	T/P.P.	Percent of Base Yr.
Total reductions without gasoline distribution limitation	25.35	55.6	25.40	55.8	27.02	59.3	27.41	60.2
Total reductions with gasoline distribution limitation	31.89	70.0	31.89	70.0	31.89	70.0	31.89	70.0
Total emissions remaining without gas distribution	20.21	44.4	20.14	44.2	18.54	40.7	18.15	39.8
Total emissions remaining with gas distribution limitation	13.67	30.0	13.67	30.0	13.67	30.0	13.67	30.0
Total allowable emissions	13.67	30.0	13.67	30.0	13.67	30.0	13.67	30.0

[1] The line-by-line emissions reductions estimated are estimated for strategies (b)-(i) as if each were applied independently; however, the "total reductions due to strategies (b)-(i)" takes into account interrelationships between them--thus, the sum of the line-by-line reductions is not equal to "total reductions due to strategies (b)-(i)."

[2] This strategy was in the T.C.P. Technical Support Document for Baltimore but not in the Federal Register.

[3] Catalytic retrofit is applied to HDV's between 1974-1977 based on N.Y.C. data.

Table 3-2. Summary of Transportation Control Plan Emission Reductions for Annual Carbon Monoxide (Metric Tons x 10^3)

	1983				1995			
	Alternative 3		Alternative 5		Alternative 6		Alternative 9	
	T/P.P.	Percent of Base Yr.	T/P.P.	Percent of Base Yr.	T/P.P.	Percent of Base Yr.	T/P.P.	Percent of Base Yr.
1972 total peak period emissions/base year	554,974	100.0	554,974	100.0	554,974	100.0	554,974	100.0
Reduction required to reach/ maintain NAAQS	316,335	57.0	316,335	57.0	316,335	57.0	316,335	57.0
STATIONARY SOURCES								
1972 stationary sources (pre-T.C.P.)	85,049	15.3	85,049	15.3	85,049	15.3	85,049	15.3
Stationary sources remaining (T.C.P. growth)	69,109	12.5	69,047	12.5	82,647	12.5	82,081	12.5
MOBILE SOURCES								
1972 mobile sources (pre-T.C.P.)	469,925	84.7	469,925	84.7	469,925	84.7	469,926	84.7
Future year mobile sources (w/FMVCP, growth, w/o T.C.P.)	221,985	40.0	232,135	41.8	134,966	24.3	165,375	29.8

Table 3-2 (continued)

	1983				1995			
	Alternative 3		Alternative 5		Alternative 6		Alternative 9	
	T/P.P.	Percent of Base Yr.	T/P.P.	Percent of Base Yr.	T/P.P.	Percent of Base Yr.	T/P.P.	Percent of Base Yr.
(a) Reduction, FMVCP minus VMT growth	247,940	44.7	237,790	42.9	334,959	60.4	304,550	54.9
Reductions, strategies (b) - (i)[1]:								
(b) Inspection/maintenance (LDV, MDV)	17,451	3.1	18,232	3.3	13,593	2.4	12,819	2.3
(c) VSAD retrofit pre-1968 LDV's	0	0.0	0	0.0	0	0.0	0	0.0
(d) (1) Air/fuel retrofit, 1968-1971 LDV's	0	0.0	0	0.0	0	0.0	0	0.0
(2) Air/fuel retrofit, 1971-1973 LDV's[2]	1,591	0.3	1,668	0.3	0	0.0	0	0.0
(e) (1) Catalytic retrofit 1971-1975 LDV, MDV	12,432	2.2	13,023	2.4	0	0.0	0	0.0
(2) Catalytic retrofit 1974-1977 HDV's[3]	11,804	2.1	12,217	2.2	0	0.0	0	0.0

Table 3-2 (continued)

	1983				1995			
	Alternative 3		Alternative 5		Alternative 6		Alternative 9	
	T/P.P.	Percent of Base Yr.	T/P.P.	Percent of Base Yr.	T/P.P.	Percent of Base Yr.	T/P.P.	Percent of Base Yr.
(f) Air/fuel retrofit, pre-1974 MDV's	285	0.1	296	0.1	0	0.0	0	0.0
(g) Air/fuel retrofit, HDV's (pre-1974)	3,059	0.6	3,165	0.6	0	0.0	0	0.0
(h) Traffic flow improvements	1,978	0.4	2,146	0.4	1,617	0.3	1,570	0.3
(i) VMT measures	1,450	0.3	1,522	0.3	1,964	0.4	2,562	0.5
Total reductions due to strategies (b)-(i)	51,112	9.2	54,679	9.9	16,787	3.0	16,302	2.9
(j) Reduction, gasoline distribution limitation	100,302	18.1	103,457	18.6	74,453	13.4	87,357	15.7
Mobile sources remaining w/o gasoline distribution limitation	170,873	30.8	177,456	32.0	118,179	21.3	149,073	26.9
Mobile sources remaining with gasoline distribution limitation	70,571	12.7	73,999	13.3	43,726	7.9	61,716	11.1
Total reductions w/o gasoline distribution limitation	314,992	56.8	308,471	55.6	354,148	63.8	325,096	58.6
Total reductions w/gasoline distribution limitation	415,294	74.8	411,928	74.2	428,601	77.2	411,177	74.1

Table 3-2 (continued)

	1983				1995			
	Alternative 3		Alternative 5		Alternative 6		Alternative 9	
	T/P.P.	Percent of Base Yr.	T/P.P.	Percent of Base Yr.	T/P.P.	Percent of Base Yr.	T/P.P.	Percent of Base Yr.
Total emissions remaining without gasoline distribution limitation	239,982	43.2	246,503	44.4	200,826	36.2	225,878	40.7
Total emissions remaining with gasoline distribution limitation	139,680	25.2	143,046	25.8	126,373	22.8	143,797	25.9
Total allowable emissions	238,639	43.0	238,639	43.0	238,639	43.0	238,639	43.0

[1] The line-by-line emissions reductions estimated are estimated for strategies (b)-(i) as if each were applied independently; however, the "total reductions due to strategies (b)-(i)" takes into account interrelationships between them--thus, the sum of the line-by-line reductions is not equal to "total reductions due to strategies (b)-(i)."

[2] This strategy was in the T.C.P. Technical Support Document for Baltimore but not in the Federal Register.

[3] Catalytic retrofit is applied to HDV's between 1974-1977 based on N.Y.C. data.

Table 3-3. Nitrogen Oxides Reductions Due to the Transportation Control Plan in the BMATS Area, As Applied to BREIS Alternatives 3, 5, 6 and 9

	1983				1995			
	Alternative 3		Alternative 5		Alternative 6		Alternative 9	
	T/P.P.	Percent of Base Yr.	T/P.P.	Percent of Base Yr.	T/P.P.	Percent of Base Yr.	T/P.P.	Percent of Base Yr.
1972 total peak period emissions/base year	121,937	100.0	121,937	100.0	121,937	100.0	121,937	100.0
Reduction required to reach/ maintain NAAQS								
STATIONARY SOURCE								
1972 stationary sources (pre-T.C.P.)	87,896	72.1	87,896	72.1	87,896	72.1	87,896	72.1
Stationary sources remaining (T.C.P. growth)	70,825	58.1	70,763	58,0	86,085	70.6	85,596	70.2
MOBILE SOURCES								
1972 mobile sources (pre-T.C.P.)	34,041	27.9	34,041	27.9	34,041	27.9	34,041	27.9
Future year mobile sources (with FMVCP, growth without T.C.P.)	36,638	30.0	35,530	29.1	44,323	36.3	34,788	28.5

Table 3-3 (continued)

	1983				1995			
	Alternative 3		Alternative 5		Alternative 6		Alternative 9	
	T/P.P.	Percent of Base Yr.	T/P.P.	Percent of Base Yr.	T/P.P.	Percent of Base Yr.	T/P.P.	Percent of Base Yr.
(a) Reduction, FMVCP minus VMT growth	-2,597	-2.1	-1,489	-1.2	-10,282	-8.4	-747	-0.6
Reductions, strategies (b) - (i) [1]:								
(b) Inspections/maintenance (LDV, MDV)								
(c) VSAD retrofit, pre-1968 LDV's								
(d) (1) Air/fuel retrofit 1968-1971 LDV's								
(2) Air/fuel retrofit 1971-1973 LDV's [2]								
(e) (1) Catalytic retrofit 1971-1975 LDV, MDV								
(2) Catalytic retrofit 1974-1977 HDV's [3]								
(f) Air/fuel retrofit, pre-1974 MDV's								
(g) Air/fuel retrofit, HDV's (pre-1974)								

Table 3-3 (continued)

	1983				1995			
	Alternative 3		Alternative 5		Alternative 6		Alternative 9	
	T/P.P.	Percent of Base Yr.	T/P.P.	Percent of Base Yr.	T/P.P.	Percent of Base Yr.	T/P.P.	Percent of Base Yr.
(h) Traffic flow improvement	-73	-0.1	-52	-0.0	-107	-0.1	-56	-0.0
(i) VMT measures	230	0.2	224	0.2	916	0.8	725	0.6
Total reductions due to strategies (b)-(i)	158	0.1	173	0.1	867	0.7	684	0.6
(j) Reduction, gasoline distribution limitation	21,414	17.6	20,613	16.9	27,377	22.5	19,985	16.4
Mobile sources remaining without gasoline distribution limitation	36,480	29.9	35,357	29.0	43,456	35.6	34,104	28.0
Mobile sources remaining with gasoline distribution limitation	15,066	12.4	14,744	12.1	16,079	13.2	14,119	11.6
Total reductions without gasoline distribution limitation	14,632	12.0	15,817	13.0	-7,604	-6.2	2,237	1.8
Total reductions with gasoline distribution limitation	36,046	29.6	36,430	29.9	19,773	16.2	22,222	18.2

Table 3-3 (continued)

	1983				1995			
	Alternative 3		Alternative 5		Alternative 6		Alternative 9	
	T/P.P.	Percent of Base Yr.	T/P.P.	Percent of Base Yr.	T/P.P.	Percent of Base Yr.	T/P.P.	Percent of Base Yr.
Total emissions remaining without gasoline distribution limitation	107,305	88.0	106,120	87.0	129,541	100.6	119,700	98.2
Total emissions remaining with gasoline distribution limitation	85,891	70.4	85,507	70.1	102,164	83.8	99,715	81,8
Total allowable emissions								

[1] The line-by-line emissions reductions estimated are estimated for strategies (b)-(i) as if each were applied independently; however, the "total reductions due to strategies (b)-(i)" takes into account interrelationships between them--thus, the sum of the line-by-line reductions is not equal to "total reductions due to strategies (b)-(i)."

[2] This strategy was in the T.C.P. Technical Support Document for Baltimore but not in the Federal Register.

[3] Catalytic retrofit is applied to HDV's between 1974-1977 based on N.Y.C. data.

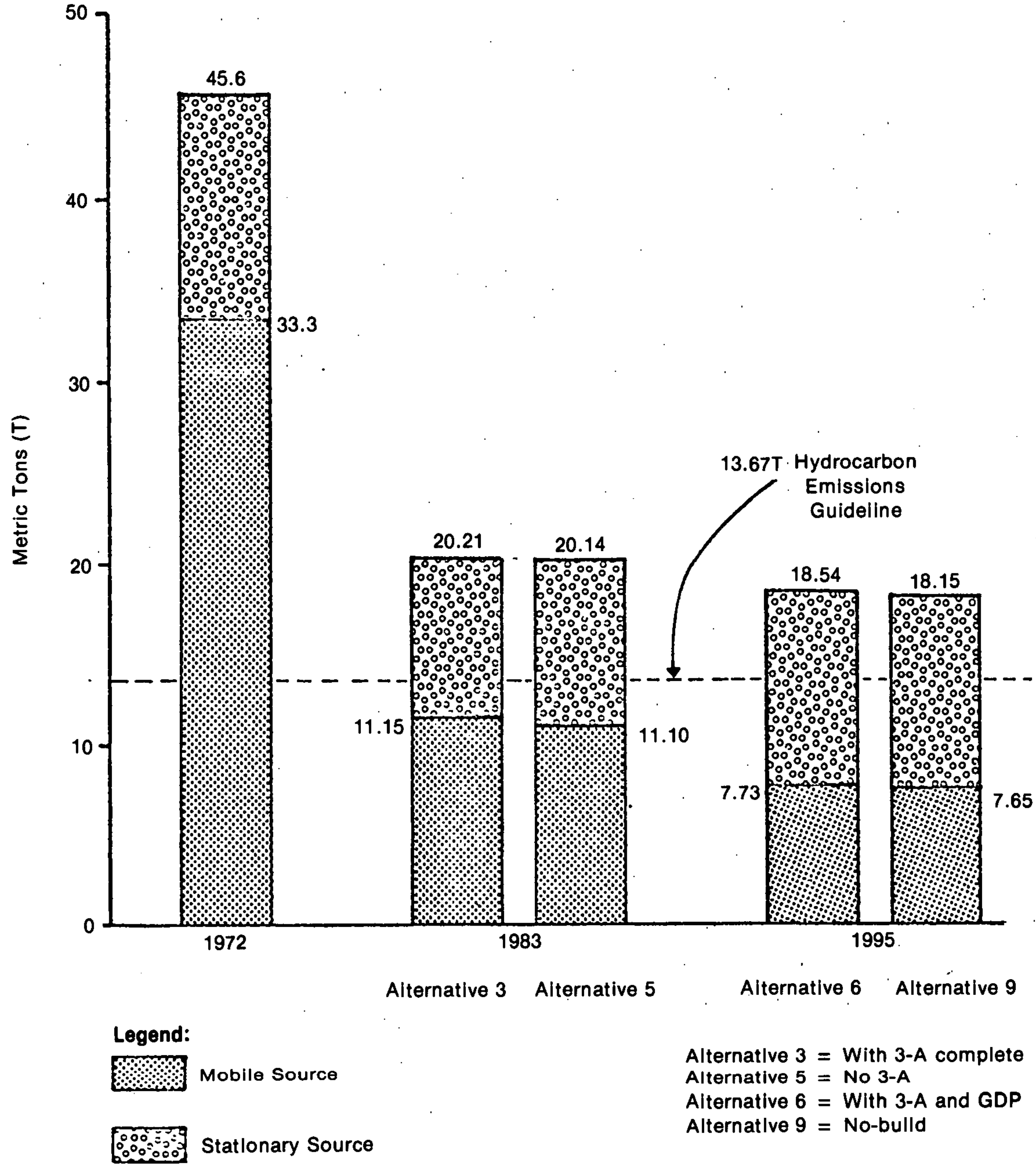

Figure 3-1. Impact of the Transportation Control Plan on Peak Period (6-9 a.m.) Hydrocarbons TCP (Minus Gas Rationing)

Figure 3–2 shows the impact of the "TCP including gas rationing" on emissions. As can be seen, the guideline will not be met in 1983 or 1995 without gas rationing.

3.3 DISCUSSION OF RESULTS

The analysis presented in this memorandum is intended to provide information to respond to two general questions:

- What is the impact of the TCP on the 3–A system and resultant emissions?
- What is the difference between emission projections with and without the 3–A?

The numerical results of the analysis must be considered within the framework of the analysis assumptions and its purpose in order to draw any conclusions from these results. The purpose and assumptions have been described in detail above. The following paragraphs list the initial conclusions relevant to the 3–A system and discuss two issues not directly considered in the analysis which may alter the conclusions in the future.

3.3.1 Impact on the 3–A System

Only those measures which affect VMT and speed have a direct impact on the 3–A system. These include:

- Traffic flow improvements
- VMT reduction measures
- Gas rationing

On a regional basis, traffic flow improvements show a very minimal impact on speed and resultant decrease in emissions. However, at the local level, they could significantly affect speed and emissions.

The VMT reduction measures provide a measureable, but very small reduction in total VMT and emissions on a regional basis. However, again at the corridor or local level they may require minor systems operation changes, and in the long term, they may alter vehicle occupancy and use patterns. If VMT growth is constrained by other measures, this would yield additional increases in traffic flow and reduced emissions.

As discussed above, gas rationing was applied as a "last resort measure." This ignores the impact of severe reductions in VMT (40-50 percent) in 1977 on projected growth and, therefore, does not directly consider the impact on the 3–A system.

If gas rationing is momentarily ignored, the initial conclusions for the impact of the TCP on the 3–A are as follows:

- The TCP will minimally improve traffic flow and increase speeds.

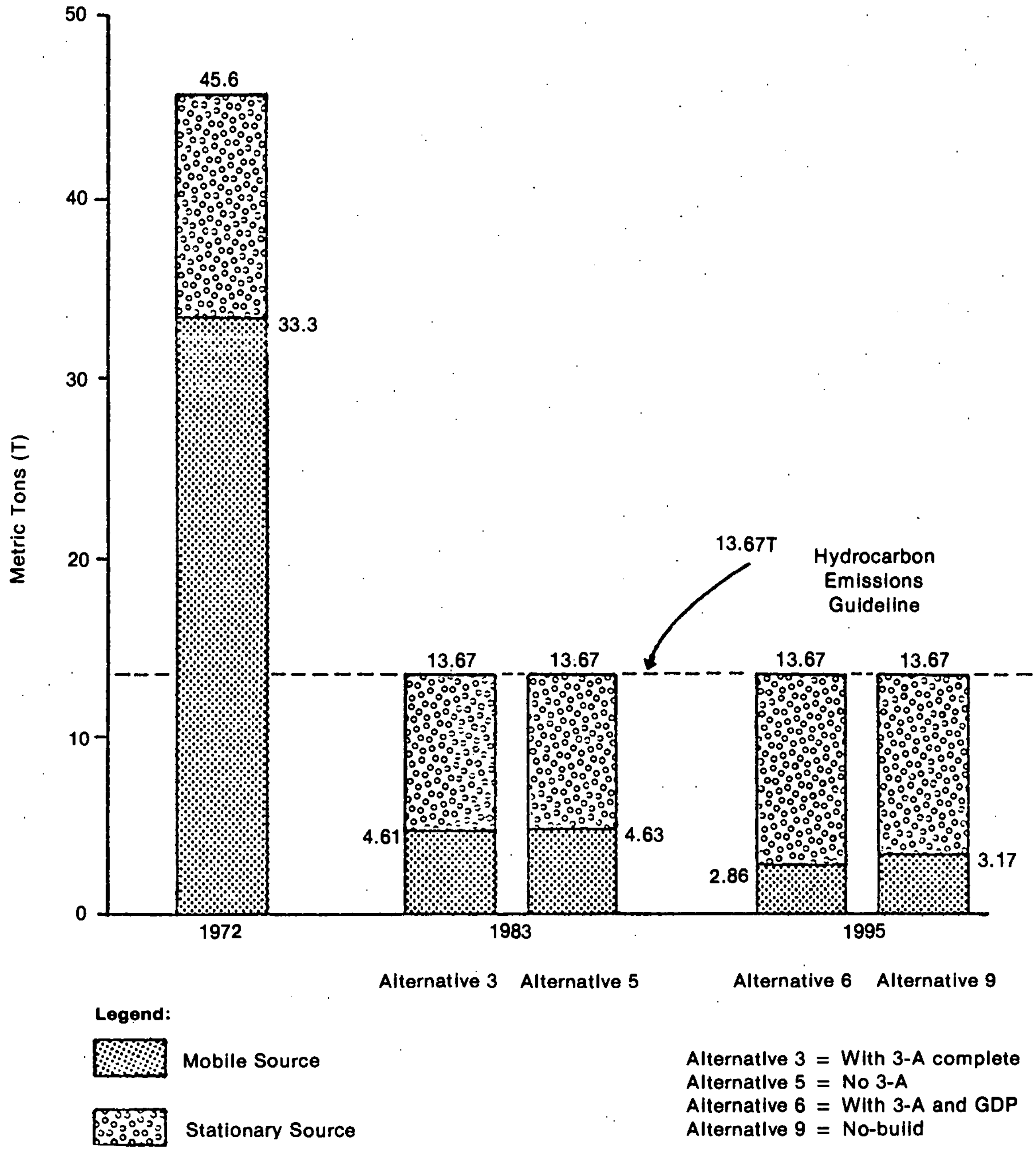

Figure 3-2. Impact of the Transportation Control Plan on Peak Period (6-9 a.m.) Hydrocarbons TCP (Including Gas Rationing)

- The TCP will minimally reduce VMT and result in some additional flow improvement.

Initial conclusions relating to resultant emissions with and without the 3–A system in 1983 are as follows:

- The TCP (not including the FMVCP, stationary source controls and gas rationing) provides less than 10 percent of the 70 percent hydrocarbon reduction required to meet the oxidant standard.

- The resultant hydrocarbon emissions both with and without the 3–A (no gas rationing) exceed the allowable emissions.

- The resultant 1983 hydrocarbon emissions with the 3–A (Alternative 3) are higher than emissions in the no-build case (Alternative 5) by approximately 0.4 percent.

- Carbon monoxide emissions reductions are within 1 percent of requirements for both alternatives in 1983 without gas rationing and well within standards by 1995.

Initial conclusions relating to resultant emissions in 1995 with the GDP and the 3–A system (Alternative 6) and the no-build case (Alternative 9) are as follows:

- The TCP (not including the FMVCP, Stationary Source Controls and gas rationing) provides less than 10 percent of the 70 percent reduction required to achieve the standards in both cases.

- The resultant hydrocarbon emissions (no gas rationing) are greater than the allowable emissions but less than 1983 emissions in both alternatives.

- The resultant emissions are higher for Alternative 6 (complete 3–A) than Alternative 9 (no-build) by approximately 2 percent.

- Stationary source emissions represent the majority of emissions in 1995 in both alternatives and are greater than 75 percent of the allowable emissions.

If gasoline rationing is applied to meet the hydrocarbon reduction guidelines:

- In 1983, about 58 percent gas rationing (VMT reduction) is required in both alternatives.

- In 1995, Alternative 6 (3–A and GDP) require 63 percent and Alternative 9 (no-build) requires 59 percent gas rationing.

3.3.2 Potential Effects of Economic or Energy Programs on Study Results

Some consideration of changes in economic growth has been given in the analysis by revising the 1983 VMT projections. However, this does not consider any major changes due to gasoline shortages, oil embargoes, major recession, etc., which may occur within the projection timeframe.

The primary assumption inherent in the analysis is that the TCP will not induce major land use changes beyond that accounted for in BREIS land use projections. The kinds of major economic or energy reduction programs mentioned above would have a major impact on land use and resultant emissions. However, any consideration of such programs is beyond the scope of this study.

3.3.3 Potential for Implementation and Effectiveness of TCP Measures

The methodology described in Section 2.0 defines assumptions on the effectiveness of each control measure. These effectiveness rates are dependent upon several factors, including:

- Mobile source (LDV, HDV, etc.) and stationary source mix
- Time period for implementation
- Implementation and operation of the control measure
- Social acceptability of the measure
- Enforcement

In addition, the resultant impact on air quality of the measures is dependent upon:

- Meteorological conditions
- Background air quality
- Growth rate of controlled and uncontrolled sources
- Assumed effectiveness and implementation of FMVCP
- Assumed vehicle turnover rate

The potential range in each of these factors should be considered independently and simultaneously in order to fully comprehend the potential impact of the TCP on the 3–A and resultant emissions and air quality. However, such a sensitivity analysis is beyond the scope of this current study and may result in a composite range of effectiveness or impact so large as to be useless for planning purposes.

For example, gas rationing has been considered as an independent variable in the analysis for two reasons:

- It is socially unacceptable and therefore has a low potential for implementation.
- Its assumed effectiveness is so large as to hide the smaller variations in results which are responsive to the analysis questions.

3.3.4 Effects of Assumptions on Results

In general, the assumptions applied are the best currently available, and they tend to be conservative in order to estimate the "worst case" future impacts. Thus, the results of this analysis are evaluated in relative terms, using comparison among alternatives rather than absolute values as the basis for evaluation.

Among the various assumptions applied, the most critical one is that related to the effects of regional future air pollution control plans.

This analysis considered mobile source emission controls, but none of the potential stationary source controls to be developed. Thus, the emission projections indicate that the stationary source emissions represent a major portion of the total emissions in 1983 and 1995.

The reason for not considering the future stationary source controls was that the analysis was intended to evaluate the "worst case" impacts. However, it should be noted that the state will have to revise the State Implementation Plan to meet air quality standards by 1977 and develop an Air Quality Maintenance Plan for the Baltimore region to attain and maintain air quality standards within the next 10 years (40 CFR 51). In addition to the promulgated Transportation Control Plan, the revised or developed plans will specify the necessary emission limitations on existing and future stationary sources. If these plans are implemented, the future stationary source emissions will be less than those estimated in this study. The 1983 and 1995 emissions may meet the 1977 hydrocarbon reduction guideline, and gasoline rationing may not be necessary.

Another assumption which may have important effects on the analysis results is that related to the effects of the promulgated Transportation Control Plans on regional vehicle miles of travel (VMT). The future VMT projections used in the analysis did not consider the potential effects of the control strategies. If the promulgated TCP is implemented prior to the 1983 or 1995 projection years, the VMT projections will be less than those originally estimated. Therefore, the mobile source emission projections can be considered as somewhat "overestimated." The quantitative effects of the TCP on regional VMT growth would require a detailed investigation.

The other assumptions, including travel parameters, vehicle mix, construction schedules, and others, may have less important effects on the analysis results. A change in these assumptions will result in a marginal to negligible change in the emission projections. However, the analysis results and conclusions are unlikely to be reversed by a reasonable change in these assumptions.

3.4 LIMITATIONS OF ANALYSIS

With the exception of those areas where new data or assumptions were used, the analysis procedures follow closely that given in the EPA Technical Support Document.(4) The limitations of the analysis include those factors which are affected by use of a regional approach:

- Regional average speeds do not adequately reflect speed correction and resultant emissions. Traffic flow improvements are underestimated, and HDV emissions are overestimated by such procedures.

- The control measure effectiveness should be considered at the level to which it applies.

Parking restrictions, bus lanes, and other measures may have a significant local impact. However, the regional level effectiveness is insignificant. In addition, one purpose of the analysis is directed at defining the fractional increase in emissions due to the 3–A system. There are two problems with interpreting the results as presented:

- The regional approach obscures the emissions reductions due to improved flow on the 3–A system.

- Since Alternative 6 includes the full GDP highway plan, the incremental effects of the 3–A system are not isolated; it must be noted, however, that the effectiveness of the 3–A depends on the supporting road system furnished by the other major highways in the region.

The results indicate that the primary impact in the long term will arise from the land uses associated with development. This should receive further analysis in the air quality maintenance plan to be developed for Baltimore.

4.0 RELATIONSHIP TO CURRENT STUDIES

The purpose of this memorandum is to update and revise, where necessary, Technical Memorandum No. 3 to include the impact of the EPA promulgated Transportation Control Plan (TCP). The methodology used was primarily that given in the EPA Technical Support Document,(2) except where it was deemed necessary to use other data, assumptions, or methods. These differences have been documented. Because the report is intended to show the impact of the TCP on the 3–A system, the 1983 completion date and 1995 long-term alternatives were selected for evaluation.

Several additional studies are currently underway which are related to the evaluation of TCP measures on a regional or subregional basis. Many such studies with independent objectives are required in the continuing processes of air quality and transportation planning implementation and evaluation. The conclusions of this current study indicate several areas where additional effort is desirable, which could be accomplished during existing or future studies.

4.1 SUBREGIONAL EVALUATIONS OF THE APPLICATION AND EFFECTIVENESS OF MOBILE SOURCE CONTROL MEASURES

Several of the VMT reduction measures and traffic flow improvement measures are applicable at only a subregional scale. The effectiveness of such measures and the implications of their effects are lost at a regional emissions analysis level. This study applied a simplified regional emissions analysis method; however, current studies such as the Traffic Management Techniques Study being performed by AMV specifically for the 3–A system may be able to generate information more useful to the design and implementation of such control measures.

A subregional or link-by-link evaluation also may take advantage of the impact of increased average speeds and their resultant effect on emissions. This effect is "washed out" by using regional average speeds.

Obviously, it would be costly, if not impractical, to apply such detailed evaluation procedures to every link in the region as in the BREIS detailed procedures, and this is not suggested. However, it would be useful to apply this level of evaluation and analysis where immediate application and implementation of such control measures is being considered.

4.2 REGIONAL EVALUATION OF THE TRANSPORTATION CONTROL MEASURES AND AIR QUALITY MAINTENANCE MEASURES

Studies are currently underway to reevaluate the Transportation Control Plan and to determine regional Air Quality Maintenance Plan requirements. As the short-term and subregional evaluation studies are completed, the results should be input to the update of long-term transportation and air quality planning. This does not necessarily require continuous updates of the previous analysis results, but does provide a process for relating the significance of such study results to the conclusions of long-term plans and analyses.

4.3 AIR QUALITY ANALYSIS UPDATES

The RPC and other agencies are currently performing sensitivity analyses and sketch planning applications. The major revisions in data base and analysis assumptions necessitated by new findings and data published during the performance of Technical Memorandum No. 9 has indicated the need for a systematic approach for updating the findings of air quality analysis. The sensitivity analyses may provide an approach to updating such analyses findings with a minimum of recalculation or reevaluation.

For example, the use of the newly proposed schedule for extension of Federal automotive emission standards and a new methodology for calculating mobile source emission factors did not greatly alter the conclusions of Technical Memorandum No. 9. However, if the assumed growth rate in stationary source emissions is shown to be much too high by new inventories, the long-term conclusions could change.

4.4 FURTHER STUDY REQUIRED

Based on the assumptions used, this analysis provides the information necessary for evaluating the effects of the Transportation Control Plan on the alternatives under consideration. As noted previously, the analysis results should be evaluated in relative terms rather than absolute values among the alternatives. This is because the analysis results are affected by the input assumptions to some extent.

Without considering the future stationary source controls, the analysis indicates that the mobile source emissions will have to be reduced by 86.2 percent while the stationary source emissions by 26.3 percent in 1983, in order to meet the 1977 hydrocarbon reduction guidelines (see Figure 3–2). Severe hardships on regional travel activities may be anticipated if the estimated amount of mobile source emission is to be reduced.

A further study is necessary to develop alternatives to the severe mobile source emission controls, particularly gasoline rationing. Emphasis may be placed on the alternative stationary source emission reductions. This further study should also assess the potential social, economic, and environmental impacts of the mobile and stationary source emission controls. Thus, it can be used as a basis for developing a balanced and comprehensive control plan compatible with the regional social, economic, and environmental goals.

Another study is recommended for reevaluating the regional VMT projections. The VMT projections used in the analysis were based on the previous BREIS work. It did not consider the effects of the Transportation Control Plan. In addition, the Energy Policy and Conservation Act of 1975 requires the state to develop State Transportation Energy Conservation plans. This will affect the regional VMT growth to a certain extent. It is recommended that a detailed study be conducted to assess the short- and long-term effects of the above-mentioned plans on the regional VMT growth. Therefore, the more accurate mobile source emission projections can be made in order to evaluate the required degree of mobile source emission control.

APPENDIX A

EXHAUST EMISSIONS METHODOLOGY

This appendix describes the methodology used to develop the mobile source exhaust emissions.

1: CARBON MONOXIDE, HYDROCARBONS AND NITROGEN OXIDES EXHAUST EMISSIONS

Light Duty Gasoline Vehicles

The equation used for calculating composite emissions from light duty gasoline vehicles during a calendar year is:

$$e_{npstwx} = \sum_{i-n-12}^{n+} c_{ipn} m_{in} v_{ips} z_{ipt} r_{iptwx}$$

where,

e_{npstwx} = Composite emission factor in grams per mile (g/mi) for calendar year n, pollutant p, average speed s, ambient temperature t, percent cold operation w, and percent hot start operation x.

c_{ipn} = The FTP (1975 Federal Test Procedure) mean emission factor for the i^{th} model year light duty vehicles during calendar year n and for pollutant p.

m_{in} = The fraction of annual travel by the i^{th} model year light duty vehicles durihg calendar year n.

v_{ips} = The speed correction factor for the i^{th} model year light duty vehicles for pollutant p, and average speed s. This variable applies to CO, HC, and NO_x only.

z_{ipt} = The temperature correction for the i^{th} model year light duty vehicles for pollutant p and ambient temperature t.

r_{iptwx} = The hot/cold vehicle operation correction factor for the i^{th} model year light duty vehicles for pollutant p, ambient temperature t, percent cold operation w, and percent hot start operation x.

The Federal Test procedure emission factor (c_{ipn}) for each specific model year vehicle was obtained from Reference 1. The fraction of annual travel (mi) was calculated, based on the vehicle population distribution and average annual miles driven for each model year vehicle. These data of population distribution and annual miles driven in the Baltimore region were obtained from EPA's "Technical Support Document for the Baltimore Transportation Control Plan."(4)

The speed correction factor is a function of average speed and several empirical coefficients. Within the range of 15 to 45 miles per hour, the speed correction factors can be calculated using the following equations:

$$v_{ips} = e^{(A + BS + CS^2)} \text{ for CO and HC}$$

$$v_{ips} = A + BS \text{ for } NO_x$$

The coefficients A, B, and C for each model year and each pollutant were obtained from Table A–1. At lower speed range, the correction factors for each pollutant are directly obtained from Table A–2.

The ambient temperature correction factors can be calculated by using the equations presented in Table A–3. The equations for computing hot/cold vehicle operation correction factor for non-catalyst and catalyst vehicles are:

$$r_{iptw} = \frac{w + (100-w)f(t)}{20 + 80\, f(t)} \qquad \text{Pre-1975 model years}$$

$$r_{iptwx} = \frac{w + x\, f(t) + (100-w-x)\, g(t)}{20 + 27\, f(t) + 53\, g(t)} \qquad \text{Post 1974 model years}$$

where:

f(t) and
g(t) = given in Table A–3
w = percent of cold operation
x = percent of hot-start operation

For pre-1975 model year vehicles, non-catalyst factors should be used
For 1975-1977, catalyst factors should be used.

TABLE A-1

LOW ALTITUDE (SPEED = 15 TO 45 MPH) COEFFICIENTS FOR SPEED CORRECTION FOR LIGHT DUTY VEHICLES

$$v_{ips} = c^{(A + S + CS^2)} \qquad v_{ips} = A + BS$$

Model Years	HC			CO			NO_x	
	A	$Bx10^{-2}$	$Cx10^{-4}$	A	$Bx10^{-2}$	$Cx10^{-4}$	A	$Bx10^{-4}$
1957-1967	0.953	-6.00	5.81	0.967	-6.07	5.78	0.808	0.980
1968	1.070	-6.63	5.98	1.047	-6.52	6.01	0.880	0.569
1969	1.005	-6.27	5.80	1.259	-7.72	6.60	0.915	0.432
1970	0.901	-5.70	5.59	1.267	-7.72	6.40	0.843	0.798
Post 1970	0.943	-5.92	5.67	1.241	-7.52	6.09	0.843	0.804

Source: AP-42-Supplement 5, December 1975, U.S. Environmental Protection Agency

TABLE A-2

LOW AVERAGE SPEED CORRECTION (LOW ALTITUDE)
FACTORS FOR LIGHT DUTY VEHICLES

	Average Speed Correction Factor for Light Duty Vehicles					
	Carbon Monoxide		Hydrocarbons		Nitrogen Oxides	
Years	8kph (5 mph)	16kph (10 mph)	8kph (5 mph)	16kph (10 mph)	8kph (5 mph)	16kph (10 mph)
1957-1967	2.72	1.57	2.50	1.45	1.08	1.03
1968	3.06	1.75	2.96	1.66	1.04	1.00
1969	3.57	1.86	2.95	1.65	108	1.05
1970	3.60	1.88	2.51	1.51	1.13	1.05
Post 1970	4.15	2.23	2.75	1.63	1.15	1.03

Driving patterns developed from CAPE-21 vehicle operation data (reference 10) were input to the modal emission analysis model (see 3.1.2.3.). The results predicted by the modal (emissions at 8 and 16 kph, 5 and 10 mph) were divided by hot FTP emission factors to obtain the above results. The above data are approximate and represent the best currently available information.

Source: AP-42-Supplement 5, December 1975, U.S. Environmental Protection Agency

TABLE A-3

LIGHT DUTY VEHICLE TEMPERATURE CORRECTION FACTORS AND HOT/COLD VEHICLE OPERATION CORRECTION FACTORS FOR FTP EMISSION FACTORS

Pollutant	Model Years	Temperature Correction Factor	Hot/Cold Vehicle Operation Correction Factors g(t)	f(t)
Carbon Monoxide				
	Non-catalyst	-0.0127t + 1.95	----	0.0045t + 0.02
	Catalyst	-0.0743t + 6.58	0.035t - 5.24	0.036t - 4.14
Hydrocarbons				
	Non-catalyst	-0.0113t + 1.81	----	0.0079t + 0.03
	Catalyst	-0.0304t + 3.25	0.0018t + 0.0095	0.0050t - 0.0409
Nitrogen Oxides				
	Non-catalyst	-0.0046t + 1.36	----	-0.0068t + 1.64
	Catalyst	-0.0060t + 1.52	-0.0010 + 0.858	0.0010t + 0.835

Source: AP-42, Supplement 5, U/S. EPA, December 1975.

The use of catalysts after 1978 is uncertain at present. For model years 1979 and beyond, the use of those correction factors which produce the highest emission estimates is suggested in order that emissions are not underestimated. The extent of use of catalysts in 1977 and 1978 will depend on the impact of the 1979 H_2SO_4 emission standard, which cannot now be predicted.

- Light Duty Gasoline Truck — The basic methodology used for light duty gasoline vehicles also applies to this category. The specific emission factors for each model year vehicle, the coefficients of calculation equations are obtained from the Reference 1.

- Heavy Duty Gasoline Vehicle — The calculation of composite emission factors for this category can be done by using the equation

$$e_{nps} = \sum_{i-n-12}^{n} c_{ipn} m_{in} v_{ips}$$

where:

e_{nps}	=	Composite emission factor in grams per kilometer grams per mile for calendar year n and pollutant p and average speed s
c_{ipn}	=	The test procedure emission factor for pollutant p in g/km (g/mi) for the i^{th} model year in calendar year n
m_{in}	=	The weighted annual travel of the i^{th} model year vehicles during calendar year n. The determination of this variable involves the use of the vehicle year distribution
v_{ips}	=	The speed correction factor for the i^{th} model year vehicles for pollutant p and average speed s

It should be pointed out that emission factors for heavy duty vehicles are based on the assumption that all operation is warmed-up vehicle operation. Ambient temperature has minimal effects on warmed-up operation. Therefore, hot/cold vehicle operation and ambient temperature correction factors are not included in this equation.

The Federal Test procedure emission factors (c_{ipn}) are given in Reference 2. The fraction of annual travel was calculated by using the data of population distribution and annual miles driven for heavy duty trucks provided in Reference 4. The equations for computing speed correction factors are the same as those of light duty vehicles, but the coefficients A, B, and C are different. The low speed correction factors are obtained from Reference 2.

Heavy-Duty Diesel Vehicles

The equations for calculating emissions from heavy duty diesel vehicles are the same as those of heavy duty gasoline vehicles. However, speed correction equations are completely different from those of the gasoline-powered vehicle. This is because there are different operating principles between these two types of engines. For the average speed less than 18 miles per hour, the correction equation is:

$$v_{ips} = \frac{\text{Urban} + \left(\frac{18}{S} - 1\right)\text{Idle}}{\text{Urban}}$$

where S is the average speed of interest (in mph) and urban and idle values are gms/minute values obtained from Table V–9 in Reference 2. For average speeds above 29 kph (18 mph), the correction factor is:

$$v_{ips} = \frac{18}{42S}\ \frac{\left[(60-S)\ \text{Urban} + (S-18)\ \text{Over the Road}\right]}{\text{Urban}}$$

where S is the average speed (in mph) of interest and urban and over-the-road values are gms/minute values obtained from Table V-3 in the Reference 2.

2: CRANKCASE AND EVAPORATIVE HYDROCARBONS EMISSION FACTORS

In addition to exhaust emission factors, the hydrocarbon emissions from gasoline motor vehicles involve crankcase and evaporative emission factors. The composite crankcase emissions for light duty gasoline vehicles can be estimated using the equation:

$$f_n = \sum_{i=1-12}^{n} h_i m_i$$

where:

f_n = The composite crankcase hydrocarbon emission factor for calendar year (n)

h_i = The crankcase emission factor for the i^{th} model year

m_i = The weighted annual travel of the i^{th} model year during calendar year (n)

The crankcase hydrocarbon emission factor by model year is obtained from Table I–24 in Reference 2.

The equation used for estimating the composite evaporative hydrocarbon emission factors for light duty gasoline vehicles is:

$$e_n = \sum_{i=n-12}^{n} (g_i + k_i d) m_i$$

where:

e_n = The composite evaporative hydrocarbon emission factor for calendar year n in grams/day (lbs/day)

g_i = The diurnal evaporative hydrocarbon emission factor or model year i in grams/day (lbs/day)

k_i = The hot soak evaporative emission factor in grams/trip (lbs/trip) for the i^{th} year

d = The number of daily trips per vehicle (3.3 trips/vehicle-day is the nationwide average)

The variables g_i and k_i are presented in Table I–27 in Reference 2 by model year.

For light duty gasoline truck and heavy duty gasoline vehicles, the composite hydrocarbon crankcase and evaporative emissions were calculated using the equation:

$$f_n = \sum_{i=n-12}^{n} h_i m_{in}$$

where:

f_n = The combined evaporative and crankcase hydrocarbon emission factor for calendar year n

h_i = The combined evaporative and crankcase hydrocarbon emission rate for the i^{th} model year. Crankcase and evaporative emissions must be combined before applying this equation

m_{in} = The weighted annual travel of the i^{th} model year during calendar year (n)

APPENDIX B

ESTIMATE OF VEHICLE MIX IN THE BALTIMORE AREA

INTRODUCTION

A number of studies are currently in progress or have recently been completed in the Baltimore area to assess the effects of vehicular travel on air quality. These studies have been done under varying sets of assumptions and with various data sets over time. Two current studies conducted by Alan M. Voorhees & Associates, Inc., (Planning Environment International) for the Interstate Division for Baltimore City have brought this problem to light particularly with respect to truck vehicle miles of travel (VMT).

The percentage of travel attributed to trucks is critical to air pollutant emissions projections and the estimate of future air quality as well as to fuel consumption and noise analyses. In order to resolve this problem, research into the available information on Baltimore truck travel was conducted and more accurate truck percentages were derived, as discussed in this memorandum.

DISCUSSION

Truck travel data in an urban area is normally compiled as part of the origin-destination surveys prepared at the time of regional transportation plan development. This is true in the Baltimore area; however, no new surveys of truck travel have been completed since 1962. This has not been critical until the need to develop a Transportation Control Plan to reduce motor vehicle emissions arose under the Clean Air Act of 1970 as part of the State Implementation Plan for Air Quality in the Baltimore Air Quality Control Region. Such a plan was promulgated by the U.S. Environmental Protection Agency on December 12, 1973. In this plan, a disputably large proportion of total baseline emissions is attributed to heavy-duty vehicles and correspondingly large emissions reductions are estimated to result from heavy-duty vehicle retrofits. Thus, the question of truck travel in the Baltimore area becomes more significant.

Unfortunately, since there has not been a major truck travel survey since 1962, there is little information from which to base estimates of current and future light duty and heavy duty truck miles of travel, as defined by the Environmental Protection Agency. Consequently, the reports in recent years that have attempted to do so have arrived at rather disparate results. Some of these reports are the Baltimore Regional Environmental Impact Study(10,11,12), the Technical Support Document for the Transportation Control Plan for the Metropolitan Baltimore Interstate Region(8), and Development of a Trial Air Quality Maintenance Plan Using the Baltimore Air Quality Control Region (1).

As the total vehicle miles of travel (VMT) estimates are fairly consistent from report to report, most of the disparity in light-duty and heavy-duty truck travel estimates is due to differences in the percentages of total VMT attributed to each type. Total daily VMT projected in the various reports is compared in Table B-1, and VMT split by vehicle type is compared in Table B-2.

The Environmental Protection Agency has recently redefined light and heavy-duty trucks as under and over 8,500 pounds gross vehicle weight (GVW) as compared to the earlier defintion of under/over 6,000 pounds GVW. Due to the definitional change and because of the earlier disparities among reports, it was considered necessary to calculate new projections of auto, light-duty truck, heavy-duty trucks, etc., percentages of total VMT, using the best information currently available, for use in BREIS Technical Memorandum No. 9 and the Traffic Management Study of the 3-A System.

The following data and methodology were used in estimating the new percentages:

A. 1970

1. The original 1970 BREIS auto versus truck VMT (88.6 percent auto/ 11.4 percent truck) is taken as a given. This figure is unaffected by the change in EPA definitions and is comparable to figures in the non-BREIS reports.

2. The 11.4 percent truck VMT is divided into light-duty and heavy-duty truck VMT as follows:

   a. Percentages of total truck trips attributable to pickup and panels (type 200000), 2-axle/single-tire (type 210000), 2-axle/dual-tire (type 220000), and "all other" trucks were estimated on the basis of Baltimore Traffic Department data taken in four locations in the BMATS area between 1966-1968.

   b. The proportions of each truck type category (pickup and panel, 2-axle/single-tire, 2-axle/dual tire, and "all other") weighing under and over 8,500 pounds GVW were estimated on the basis of Federal Highway Administration

TABLE B-1

TOTAL DAILY VEHICLE MILES OF TRAVEL PROJECTIONS
IN THE BMATS AREA[1]
(millions)

Year of Estimation	BREIS[2,5]	T.C.P.	Trial A.Q.M.P.[4]
1970	17.842		
1972		17.706	
1977		20.247	
1980	25.642 (Alt. 5)		22.516
1985			24.588
1995	28.599 (Alt. 9)		

[1]The study area used in the Baltimore Metropolitan Area Transportation Study.

[2]The Baltimore Regional Environmental Impact Study (10,11,12)

[3]The Technical Support Document for the Transportation Control Plan for Metropolitan Baltimore Intrastate Region (8)

[4]Development of a Trial Air Quality Maintenance Plan Using the Baltimore Air Quality Control Region (1)

[5]The BREIS vehicle miles of travel estimates do not include bus vehicle miles of travel, which are estimated separately.

TABLE B-2

AUTO AND TRUCK PERCENTAGES
OF TOTAL DAILY VMT IN THE BMATS AREA[1]

Vehicle Classification	BREIS[2,5] 1970	BREIS 1980	BREIS 1995	T.C.P.[3] 1972	T.C.P. 1977	Trial A.Q.M.P.[4] 1977	Trial A.Q.M.P. 1980	Trial A.Q.M.P. 1995
Automobiles	88.6	89.5	89.6					
				88.0	86.0	87.5	87.3	87.1
Trucks, ≤6000#GVW	9.6	8.9	8.8					
Trucks, 6,000-10,000 #GVW								
				10.7	12.5	12.5	12.7	12.9
Gasoline Trucks, ≤ 10000#GVW	1.8	1.6	1.6					
Diesel Trucks, ≤ 10000 #GVW								
				1.3	1.5			
Diesel Bus, ≤10000 #GVW								

[1]The study area used in the Baltimore Metropolitan Area Transportation Study.

[2]The Baltimore Regional Environmental Impact Study.(10,11,12)

[3]The Technical Support Document for the Transportation Control Plan for Metropolitan Baltimore Intrastate Region.(8)

[4]Development of a Trial Air Quality Maintenance Plan Using the Baltimore Air Quality Control Region.(1)

[5]The BREIS VMT split by vehicle type does not include bus VMT, because bus VMT is estimated separately

Truck Weight Study loaded weight data taken in five locations in the Baltimore region between 1969-1974.

c. Adjusting a) by b), the percentages of total truck trips attributable to under 8,500 pounds GVW trucks and over 8,500 pounds GVW trucks were calculated.

d. The under/over 8,500 pounds GVW truck trips split was converted into an under/over 8,500 pounds GVW truck VMT split by adjusting for the relatively larger trip lengths of heavy trucks, based on data from Motor Trucks in the Metropolis; the light-duty/heavy-duty truck VMT split arrived at was 39 percent light-duty and 61 percent heavy-duty.

e. Multiplying the 11.4 percent of total VMT attributable to trucks by the 39 percent light-duty/61 percent heavy-duty split results in 4.45 percent of total VMT attributable to light-duty trucks and 6.5 percent attributable to heavy-duty trucks in 1970.

3. The 7.0 percent heavy-duty truck VMT is divided into heavy-duty gasoline truck VMT and heavy-duty diesel truck VMT percentages as follows:

a. A gasoline/diesel heavy-duty truck registration split for Maryland State was determined according to data given in the 1972 Census of Transportation, Truck Inventory and Use Survey.

b. A Baltimore region gasoline/diesel heavy-duty truck registration split was obtained by adjusting the Maryland state split for probable differences between metropolitan region versus state gasoline/diesel heavy-duty truck splits. The adjustments were based on data from the New York City metropolitan region and N.Y. State, obtained from the New York City Department of Air Resources and the 1972 Census of Transportation.

c. A Baltimore region gasoline/diesel heavy-duty truck VMT split was obtained by adjusting the Baltimore registration split calculated in b) for the relatively larger trip lengths of diesel versus gasoline heavy-duty trucks, based on trip lengths given in the 1972 Census of Transportation; the gasoline/diesel heavy-duty truck split arrived at was 72 percent gasoline and 28 percent diesel VMT.

d. Multiplying the 6.95 percent of total VMT attributable to heavy-duty trucks by the 72 percent gasoline/28 percent diesel split results in 5.0 percent of total VMT attributable to heavy-duty gasoline trucks and 1.95 percent attributable to heavy-duty diesel trucks in 1970.

4. Bus VMT are estimated on the basis of figures from the Baltimore M.T.A. and are not part of "total VMT" as given in BREIS Technical Memorandum No. 3. Thus, it is not necessary to estimate the percentage of total VMT due to buses.

B. 1972, 1983, 1995

1. Differential growth rates of truck versus auto VMT are assumed; however, all truck types are assumed to grow at the same rate.

2, Assuming 4.6 percent auto and 6.2 percent truck annual VMT growth rates between 1970 and 1972, an 88.3 percent auto/11.7 percent truck total VMT split in 1972 is calculated. The growth rates are based on national average figures taken from the National Transportation Statistics, Automobile Facts and Figures, and Motor Truck Facts. These figures reflect somewhat faster growth of truck versus auto travel and the relatively fast growth of both types of travel before the current energy situation.

3. Assuming 2.5 percent auto and 2.75 percent truck annual VMT growth rates between 1972 and 1995, an 88.0 percent auto/12.0 percent truck total VMT split in 1983 and on 87.7 percent auto/ 12.3 percent truck total VMT split in 1995 is calculated. The growth rates are extrapolated from Engineering Science's Trial Air Quality Maintenance Plan estimates for 1977-1985, ostensibly obtained from the Baltimore Regional Planning Council. These figures reflect slightly faster growth of trucks versus auto travel and the relatively slow growth of both types of travel during/ after the current energy situation.

4. Light-duty truck, heavy-duty diesel truck, and heavy-duty gasoline truck percentages in 1972, 1983, and 1995 were adjusted proportionally, as all truck types are assumed to grow at the same rate.

Percentages of total daily VMT by vehicle type categories for 1970, 1972, 1983, and 1995 are summarized in Table B-3.

Because a greater percentage of automobile VMT occurs during the 6-9 a.m. peak period than truck VMT, adjustments to the Table B-3 daily VMT percentages were necessary to obtain percentages of total 6-9 a.m. VMT by vehicle type categories. These adjustments reflected estimates of 26 percent of auto daily VMT in the 6-9 a.m. peak period, based on BREIS figures, and 17 percent of light-duty truck, 20 percent of heavy-duty truck daily VMT in the 6-9 a.m. peak period, based on Motor Trucks in the Metropolis figures. The 6-9 a.m. peak period VMT percentages by vehicle type for 1970-1995 are summarized in Table B-4.

TABLE B-3

PERCENTAGES OF 24-HOUR VMT BY VEHICLE TYPE CATEGORY, BY DESIGN YEAR

	1970	1972	1983	1995
Automobile	88.6	88.3	88.0	87.7
Light-Duty Truck	4.45	4.55	4.7	4.8
Heavy-Duty Gasoline Truck	5.0	5.15	5.25	5.4
Heavy-Duty Diesel Truck	1.95	2.0	2.05	2.1

TABLE B-4

PERCENTAGES OF 6-9 A.M. VMT BY VEHICLE TYPE CATEGORY, BY DESIGN YEAR

	1970	1972	1983	1995
Automobile	91.5	91.2	91.0	90.8
Light-Duty Truck	3.0	3.1	3.2	3.25
Heavy-Duty Gasoline Truck	4.0	4.1	4.2	4.3
Heavy-Duty Diesel Truck	1.5	1.6	1.6	1.65

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APPENDIX C

METHODOLOGY AND ASSUMPTIONS FOR ESTIMATING THE EFFECTIVENESS OF VMT REDUCTION MEASURES

This appendix describes the general assumptions and methodology for determining the effectiveness of VMT reduction measures. The effectiveness of VMT reduction measures is dependent upon two primary variables:

- Exposure — the percent of VMT exposed to the measure
- Capture — the percent of exposed VMT which can be expected to be reduced or shifted to other modes

1. BUS AND CARPOOL LANE

Preferential lanes for high-occupancy vehicles are established in all radial corridors. Assuming that in a.m. peak traffic (6-9 a.m.) high-occupancy vehicles get a five-minute relative travel time advantage compared to the null situation, the exposure and capture rates can be estimated as follows.

1.1 Estimated VMT Reduction Due to Shift to Buses

(1)	Exposure	=	Percent of VMT exposed to the preferential lanes
		=	Percent of work trips destined for CBD and adjacent zones (117, 118, 119, 120, 121) (from BREIS Technical Memorandum No. 1 = 30 percent)
		x	Percent of work trips made between 6 and 9 a.m. (assumed to be equal to 4-6 p.m.) (from BREIS Technical Memorandum No. 2 = 32 percent)
		x	2 (to account for return trips in p.m.)
		x	Percent that work trip VMT is of total 24-hour VMT (from BREIS Technical Memorandum No. 2 = 30 percent)
		=	.30 x .32 x 2 x .30
		=	.0576 or 5.76 percent of total 24-hour VMT
(2)	Capture	=	Increase in percent of total person work trips using transit (assuming a five-minute travel time differential in favor of buses, all other factors held constant).

Based on Baltimore Work Mode Choice Model for Moderate Parking Cost (9¢ to 29¢ per hour) and income levels 5 and 6, the slope of the mode choice curve approximates -.32.

Capture = .32 (5 minutes) = 1.6 percent

The Shirley Highway Experience may be a more analogous situation, although the busway provided a much larger travel time difference than in the case being analyzed. Transit's share of total corridor person trips increased 13 percent, and the travel time advantage was 15-20 minutes compared with bus operation prior to the busway. Using the proportional method, the capture would be 3.7 percent if the travel time advantage was reduced to five minutes. For the purpose of this study, the capture ranging from 1.6 to 3.7 percent was used.

(3) Vehicle Trip Reduction Factor — For each person trip shifted from auto to bus, less than one auto trip is eliminated since persons are shifting from autos with average occupancies of 1.30 persons per car.

$$\text{Trip reduction factor} = \frac{1}{1.30} = \underline{0.77}$$

(4)
- Percent 24-hour VMT reduction in 1983 =

  .0576 x .016 x .77 = .00071 (lower limit)

  .0576 x .037 x .77 = .00165 (upper limit)

  or .071 to .165 percent

- Percent 6-9 a.m. VMT reduction (2.5 times 24-hour percent) in 1983 =

  0.18 to 0.41 percent

- Percent 24-hour VMT reduction (3.33 times 1983—24-hour percent) in 1995 =

- Percent 6-9 a.m. VMT reduction in 1995 = .24 to .55 percent

1.2 Estimated VMT Reduction Due to Shift in Carpools

(1) Exposure = Same as for shift to buses

= 5.76 percent of total VMT

(2) Capture = California experience at Bay Bridge and Los Angeles priority ramps indicate that 6 to 12 percent of total persons using the preferential facility during peak periods will shift to carpools when a five-minute travel time differential is created.

Use 6 to 12 percent

(3) Adjustments due to vehicle trip reduction from shift to carpools (assuming mean occupancy of carpools using preferential lanes is 3.3) and extra distance traveled to pick up carpool partners (15 percent circuity)

$$\text{Adjustment Factor} = 1 - \frac{1}{\text{average carpool occupancy}} \text{(circuity factor)}$$

$$= 1 - \frac{1}{3.3}\ (1.15) = \underline{.65}$$

(4)

- Percent 24-hour VMT reduction in 1983 =

  $$.0576 \times .06 \text{ to } .12 \times .65 = .0022 \text{ to } .045$$

  or .22 to .45 percent

- Percent 6-9 a.m. VMT reduction (2.5 times 24-hour percent) in 1983 =

  .55 to 1.12 percent

- Percent 24-hour VMT reduction = percent 6-9 a.m. VMT reduction in 1995 =

  3.33 times 1983—24-hour reduction =

  .73 to 1.5 percent

2. EMPLOYER-BASED CARPOOL MATCHING AND PROMOTION (INCLUDING SPONSORED INCENTIVES)

(1) Exposure = Percent of employees exposed

x Percent that work trip VMT is of total VMT (from BREIS Technical Memorandum No. 2, percent = 30 percent)

Employers exposed are assumed to be 50 percent of prime employers (those working for large employers (greater than 250) in manufacturing, institutional, and governmental classifications) plus 25 percent of the remainder of employees.

From Technical Memorandum No. 1, page D–14, 1980 Prime employees = 33 percent of total.

Therefore, percent of employees exposed = $\frac{.50}{.33}$ (.33) + .25 (.67)

Exposure = .33 x .30 = .10 of 24-hour VMT

(2) Capture — The most successful employer-sponsored programs capture an average of 15 percent of total employees.

In Portland's areawide program, 12 percent of the employees exposed joined carpools.

Assuming Baltimore will not equal the most successful efforts, assume a range of 5 to 10 percent capture.

(3) Vehicle trip reduction factor =

$$1 - \frac{1}{\text{average carpool occupancy}} \text{ (circuity factor)} =$$

$$1 - \frac{1}{2.5} \ (1.15) = \underline{.54}$$

(4)

- Percent 24-hour reduction in 1983 =

  .10 x .05 x .54 = .0027
  to to
  .10 = .0054

  or .27 to .54 percent

- Percent 6–9 a.m. VMT reduction in 1983 (2.5 times 24-hour percent) =

  .68 to 1.35 percent

- Percent 24-hour VMT reduction =

  6–9 a.m. VMT reduction in 1995 =

  3.3 x 24 percent reduction in 1983 =

  .9 to 1.8 percent

Table C–1 summarizes the estimated VMT reduction potential for each of the abovementioned measures.

TABLE C–1

EFFECT OF VMT REDUCTION MEASURES

VMT Reduction Measure	1983 Percent VMT Reduction		1995 Percent VMT Reduction	
	6-9 a.m.	24-hour	6-9 a.m.	24-hour
Preferential Lanes Shift to Buses	.18 to .41	.07 to .16	.24 to .55	.24 to .55
Shift to Carpools	.55 to 1.12	.22 to .45	.73 to 1.5	.73 to 1.5
Employer-Based Carpool Incentives	.68 to 1.35	.27 to .54	.09 to 1.8	.09 to 1.8
TOTAL	1.41 to 2.88	.56 to 1.15	1.87 to 3.85	1.87 to 3.85